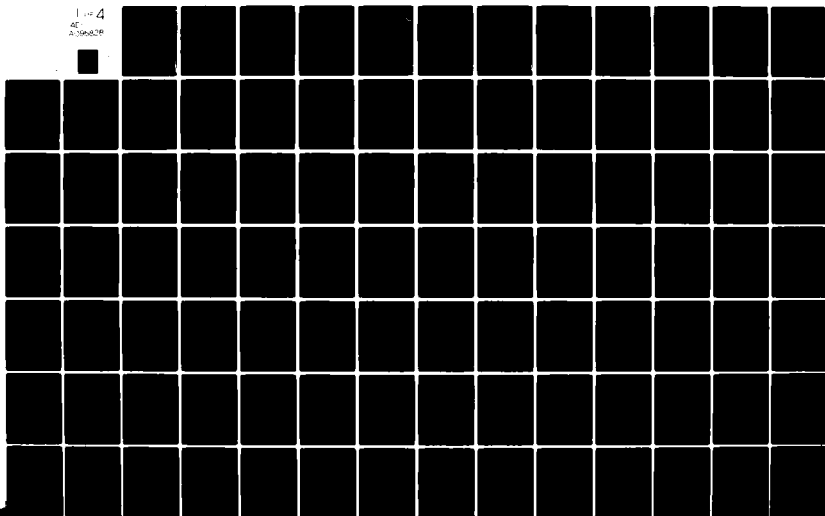


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**A SYSTEMS EVALUATION OF THE ENVIRONMENTAL IMPACT
OF THE AUBREY RESERVOIR PROJECT ON ELM FORK
OF THE TRINITY RIVER IN NORTH TEXAS**

BY

**THE INSTITUTE FOR ENVIRONMENTAL STUDIES
NORTH TEXAS STATE UNIVERSITY
DENTON, TEXAS**

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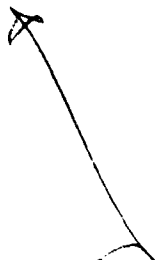
Final report submitted to the U.S. Army Corps of Engineers, Fort Worth District
in fulfillment of Contract DACW63-72-C-0052, on 30 June 1972.

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20. environmental effects and maximize the positive attributes of the project.



A SYSTEMS EVALUATION OF THE ENVIRONMENTAL IMPACT
OF THE AUBREY RESERVOIR PROJECT ON ELM FORK
OF THE TRINITY RIVER IN NORTH TEXAS.

by

Final Rept.

THE INSTITUTE FOR ENVIRONMENTAL STUDIES

NORTH TEXAS STATE UNIVERSITY

DENTON, TEXAS

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Final report submitted to the U.S. Army Corps of Engineers,
Fort Worth District,
in fulfillment of Contract DACW63-72-C-0052
on 30 June 1972 *13*

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North Texas
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76203

Institute
for
Environmental
Studies

June 30, 1972

Mr. L. E. Horsman
Fort Worth District
Corps of Engineers
P. O. Box 17300
Fort Worth, Texas 76102

Dear Mr. Horsman:

The Institute for Environmental Studies at North Texas State University is pleased to submit its final report on "A Systems Evaluation of the Environmental Impact of the Aubrey Reservoir Project on Elm Fork of the Trinity River in North Texas." This report is the result of research performed by the Institute for the Army Corps of Engineers under contract number DACW63-72-C-0052.

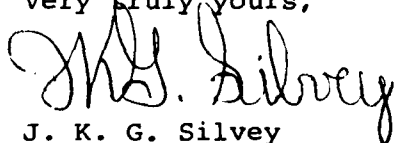
This report summarizes in detail the results of a systematic and interdisciplinary study of major environmental elements in the proposed Aubrey Reservoir Site, and our evaluation of the Reservoir's impact on them. Our environmental statement contains a brief description of the Aubrey project; descriptions, results, and discussion of the Battelle-Columbus Environmental Evaluation System (EES) which we used to provide the Army Corps of Engineers with a numerical environmental impact index for the Aubrey Reservoir; and assessment of the current status of selected environmental elements, and evaluations of the Reservoir's impact on them; and our recommendations to ameliorate the negative effects of the Reservoir and enhance its positive attributes.

Mr. L. E. Horsman
page 2

We wish to take this opportunity to state that since the contract was signed on 16 March 1972, and a draft of the report was due on 15 June 1972, our results are based on only 3 months of intensive and extensive field work. A study of this magnitude normally requires at least a year to complete. However, we believe that our intensive efforts and use of the Battelle-Columbus EES enabled us to capture the essence of the impact of the Aubrey Reservoir Project on the environmental elements and parameters discussed in this report.

The Institute for Environmental Studies appreciates the opportunity to assist the Army Corps of Engineers in maintaining the quality of our environment by preparing this environmental impact statement for the Aubrey Reservoir Project. We would welcome the opportunity to assist the Corps further by evaluating the impact of other projects in the Trinity River Basin. Our experience in the application of the Battelle-Columbus EES during this study would enable us to perform a comprehensive environmental evaluation of the Corps' development of the Trinity River Basin. Our experienced team, using a modified version of the EES, could provide the Corps with numerical impact indices which could be directly compared among projects and used in making decisions among alternatives for each project.

Very truly yours,



J. K. G. Silvey
Director, Institute for
Environmental Studies

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EXECUTIVE SUMMARY

In response to provisions of the National Environmental Policy Act of 1969, the U.S. Army Corps of Engineers contracted with the Institute for Environmental Studies at North Texas State University to assess the environmental impact of the Aubrey Reservoir Project on Elm Fork of the Trinity River in North Texas. This report summarizes the results of a 3 months' systematic study by an interdisciplinary team from the Institute of Environmental Studies to evaluate the environmental impact of the Aubrey Reservoir Project. This study was comprehensive, making use of the professional disciplines represented by the research team: fisheries management, water quality and resource management, population biology, plant ecology, invertebrate and vertebrate ecology, community and systems ecology, history, physical geography, demography, and cultural and economic geography.

The environmental impact of the Aubrey Reservoir Project was quantified by using the most recent Environmental Evaluation System (EES) developed for the Bureau of Reclamation by Battelle-Columbus Laboratories (1). The EES provides a relatively sensitive instrument with which environmental impacts of water resource projects can be evaluated. Essentially, the EES abstracts or models a complex environmental system which has evolved through long term interactions among biological, physical and cultural elements into four categories, 18 components, and 78 parameters. The categories and components are:

| | |
|--------------------------|-------------------------|
| Ecology | Environmental Pollution |
| Species and Populations | Water Pollution |
| Habitats and Communities | Air Pollution |
| Ecosystems | Land Pollution |
| | Noise Pollution |
| Esthetics | Human Interest |
| Land | Educational-Scientific |
| Air | Packages |
| Water | Historical Packages |
| Biota | Cultures |
| Man-made Objects | Mood-Atmosphere |
| Composition | Life Patterns |

The parameters represent significant specific attributes of the environment which are relevant to water resource projects.

The quality of these parameters or "handles" on the environment was determined in the field and from the literature and expressed quantitatively as a percentage of the Parameter Importance Units (PIU) for each. A total of 1000 points were distributed among the 78 parameters according to the Battelle-Columbus EES so that each was assigned a maximum PIU commensurate with its relative importance. The present quality, without the project, was determined for each parameter as a percentage of its maximum PIU. The change in quality of each parameter with the project was assessed. The summation of these changes is the numerical environmental impact index of the Aubrey Project.

This report is divided into three major parts: 1) the use, description, results, discussion and summary of the Battelle-Columbus EES; 2) reports on the Botanical Elements, Zoological Elements, Archaeological-Historical-Cultural Elements, and Demographical-Economical-Cultural Elements in the proposed Aubrey Reservoir site; and 3) general recommendations to ameliorate the negative impact and enhance the positive attributes of the Aubrey Reservoir. Specific recommendations are made in the parameter and elements reports.

A SYSTEMS EVALUATION OF THE ENVIRONMENTAL
IMPACT OF THE AUBREY RESERVOIR PROJECT ON
ELM FORK OF THE TRINITY RIVER IN
NORTH TEXAS

INTRODUCTION

Provisions of the Environmental Policy Act of 1969 require that projects supported by federal funds which will modify the environment must be preceded by a statement evaluating their environmental impact. The Aubrey Reservoir Project will modify an existing environmental system which has evolved through long-term interactions among biological, physical and cultural elements. Evaluation of the immediate and future environmental impact of the Aubrey Reservoir Project on this complex system requires a holistic approach combining techniques of systems analysis with intensive and extensive on-site field investigation by a coordinated team of specialists from biological, physical and social sciences.

A team from the Institute for Environmental Studies representing the following disciplines was assembled to study and evaluate the environmental impact of the Aubrey Reservoir Project: fisheries management, water quality and resource management, population biology, plant ecology, invertebrate and vertebrate ecology, community and systems ecology, history, physical geography, demography, and cultural and economic geography.

The major objectives of this study were:

1. To provide the Army Corps of Engineers with a numerical index of the environmental impact of the Aubrey Reservoir Project on four environmental categories (Ecology, Environmental Pollution, Esthetics and Human Interest) which can be used in objective decision making among alternative project sites or project modifications; and for direct comparisons with future reservoir projects, especially in the Trinity River Basin.

2. To assess the current environmental setting in terms of Botanical, Zoological, Archaeological-Historical-Cultural, Geological, Hydrological-Water Quality, and Demographical-Economical-Cultural Elements in the site of the proposed Aubrey Reservoir Project, and to evaluate the project's impact on them.
3. To recommend specific and general procedures which will ameliorate negative environmental impacts and enhance the positive attributes of the Aubrey Reservoir Project.

The content of the statement on the environmental impact of the Aubrey Reservoir Project is presented in this report in four parts. The first contains a general physical description of the Aubrey Reservoir Project and its site. The second contains the description, results, discussion and summary of the Environmental Evaluation System used to arrive at the numerical index of the environmental impact of the Aubrey Reservoir Project. The third contains detailed description and discussion of the environmental elements, evaluations of the impact of the Aubrey Reservoir Project on them and specific recommendations to reduce any negative impacts. The fourth contains general recommendations to ameliorate the negative environmental effects and maximize the positive attributes of the project.

Sections two and three represent our attempt to provide the Army Corps of Engineers with a more comprehensive statement of the impact of the Aubrey Reservoir Project. Essentially, we are combining a "new", virtually untested-in-the-field, quantitative approach with a more "traditional" descriptive or qualitative one. Because of this, our report contains a certain element of redundancy.

Although our study was systematic, interdisciplinary and comprehensive in both qualitative and quantitative aspects, it must be realized that our statement on the environmental impact of the Aubrey Reservoir Project is based on only 3 months of extensive and intensive field study. Therefore, the results in this report should not be construed as definitive, nor do they represent the last word on the effects of the Aubrey Reservoir Project on all the important environmental parameters.

Although additional time would have resulted in a report with a higher resolution, it is the opinion of this eval-

uation team that our statement captures the essence of the environmental impact of the Aubrey Reservoir Project. Therefore, the Army Corps of Engineers should be confident in using our results and recommendations in making decisions concerning the Aubrey Reservoir Project.

Throughout this report we refer to Garza-Little Elm Reservoir and Lake Dallas. These now officially are called Lewisville Lake. However, because the recent change in name has not become common knowledge, we used the former names here. Lake Dallas was the original and smaller reservoir which is now part of the newer larger reservoir known as Garza-Little Elm.

STATEMENT OF THE ENVIRONMENTAL IMPACT OF
THE PROPOSED AUBREY RESERVOIR PROJECT

The following is the content of our statement of the environmental impact of the Aubrey Reservoir Project.

General Description of the
Aubrey Reservoir and its Site

The site of the multipurpose (i.e., flood control, water conservation, recreation and water supply to metropolitan areas of Denton and Dallas) Aubrey Reservoir is located in parts of Denton, Cooke and Grayson Counties of North Central Texas (Plate I). The geographical grid location of the proposed impoundment is between $33^{\circ} 20' 00''$ and $33^{\circ} 32' 30''$ north latitude, and between $96^{\circ} 52' 30''$ and $97^{\circ} 10' 00''$ west longitude. The major impoundment will be along Elm Fork and Isle du Bois and their tributaries in Denton County. The reservoir will extend into the southern part of Cooke County along Elm Fork, Indian Creek and Wolf Creek valleys. Only the southwestern portion of Grayson County along Buck Creek and Range Creek valleys will be in the reservoir basin.

The drainage area or watershed covers 692 square miles in Montague, Cooke, Grayson and Denton Counties. Tributaries of Elm Fork gather water from within 1 mile of the Red River just north of Gainesville, Texas. The watershed extends into Montague County along Elm Fork, into southern Cooke County along numerous tributaries, into southwestern Grayson County along Buck Creek and Range Creek, and along Elm Fork and Isle du Bois, and their tributaries in Denton County.

The dimensions, elevations and capacities of the proposed Aubrey Reservoir are seen in Table 1.

Table 1. Dimensions, elevations and capacity of the Aubrey Reservoir*

| Item | Unit |
|---|--------------------------------|
| Drainage Area | 692 (square miles) |
| Top of Dam | 657.0 (Ft. MSL) |
| Design W.S. (1000 Ft. Uncontrolled Broadcrest Spillway) | 651.6 (Ft. MSL) (Not Final) |
| Upper Guide Contour | 641.0 (Ft. MSL) |
| Top of Flood Control Pool | 636.0 (Ft. MSL) |
| Top of Conservation Pool | 627.0 (Ft. MSL) |
| Stream Bed | 528.0 (Ft. MSL) |
| Flood Storage | 249,000 (Acre-Feet) |
| Flood Storage | 6.7 (In. of runoff) |
| Conservation Storage | 627,400 (Acre-Feet) |
| Sediment | 54,600 (Acre-Feet) |
| Total Storage | 931,000 (Acre-Feet) |
| Yield-Initial | 134.0 (CFS) |
| Yield-Initial | 86.6 (MGD) |
| Yield Ultimate | 117.0 (CFS) |
| Area at Upper Guide Contour | 35,050 (Acres) |
| Area at Top of Conservation Pool | 25,300 (Acres) |

*Data obtained from Army Corps of Engineers, Fort Worth District for Dam Site No. 1.

The proposed site is located mainly in the physiographic subregions known as the Grand Prairie and Eastern Cross Timbers. The Grand Prairie is underlain by thin limestone beds, whereas the Eastern Cross Timbers is underlain by a mixture of sands, clays and sandstone. A small section in the extreme eastern part of the reservoir site at the headwaters of Range and Buck Creeks is in a third subregion, the Blackland Prairie, which is underlain by Eagleford shales.

The Grand Prairie dips seaward with a main scarp located at its junction with the Western Cross Timbers. Numerous minor scarps occur within its boundaries. The width of the Grand Prairie in Texas rarely exceeds 25 miles. It is a rolling plain upon which grasses are the major vegetation (i.e., midgrass prairie). Streams generally follow outcrops, but occasionally cut across them to give

the area a south to south-east drainage pattern. The major formations of the Grand Prairie located in and near the reservoir site are: Duck Creek (marl and limestone), Fort Worth (limestone and some marls), Denton (clay), Weno (limestone), Pawpaw (sandstone, some sandy clay loosely cemented and cross-bedded), and the Grayson marl (mostly marl with some thin interbeds of limestone). The stream valleys of the Grand Prairie are regions of aggradation with fluviatile terrace deposits laid down in the Pleistocene and with flood plain alluvium in the lower valleys (see Plate II).

The Eastern Cross Timbers form a band of post oaks across the region on an outcrop of Woodbine sandstone. This formation consists of Dexter, Lewisville and Templeton members. The Eastern Cross Timbers appears as a region of high and rolling knolls when viewed from the Grand Prairie. Erosion in this region has produced deeper and steeper-sided valleys than those in the sections of the reservoir site on the Grand Prairie. Pleistocene deposits of terraced materials are found along Isle du Bois Creek and its tributaries. However, the valley floor of Isle du Bois has been widened and covered by flood plain deposits of recent times.

The climate* of the watershed region is humid-subtropical. It is characterized by short and mild winters with mean monthly temperatures of 46.1, 44 and 48.1 F during December, January and February, respectively. The lowest official temperature was -12 F. The area enjoys a long growing season (average of 222 frost-free days). Summers are hot, with June, July and August temperatures averaging over 80 F. The maximum official temperature was 114 F. The temperature exceeds 99 F an average of 31 days per year.

The mean annual precipitation is 33.67 inches. The range is from 20.37 to 52.79 inches. Rainfall is distributed throughout the year with a definite concentration in the months of April (3.65), May (4.93) and June (3.80 inches). The driest portion of the year occurs during November (2.13), December (2.14), January (1.97) and February (2.22 inches). The mean monthly relative humidity

* The Gainesville station was selected for climatic data since it is in the upper portion of the watershed.

varies between 50 and 65% throughout the year. The average annual evaporation for area reservoir surfaces recorded by the Denton Agricultural Experiment Station is 53.22 inches.

The watershed area is affected by occasional drought periods that may last for several years. Major droughts occurred during the years of 1908-1913 and from 1950-1957 over the basin. Minor droughts occur more frequently.

The 35,050 acres (at upper guide contour) of the site are divided into the following vegetation or community types: Abandoned Old Field (26,635 acres); Upland Post Oak Forest (3,438 acres); Streamside Forest (1,116 acres); and Cultivated (3,861 acres). Although the climate favors midgrass prairie, the sandy soil derived from the Woodbine sandstone supports the post oak Cross Timbers. Prior to 1835 almost the entire area of the site was covered with post oaks. Man's activities have reduced them to their present condition. Even the best stands are seriously disturbed by grazing and cutting.

Environmental Evaluation System

Description

The environmental system which will be modified by the Aubrey Reservoir Project has evolved through long-term interactions among biological, physical and cultural elements. It is impossible to assess the impact of the Aubrey Reservoir Project on all of these elements. Therefore, this complex system must be abstracted into selected elements and parameters which capture the essence of the environment, i.e., those elements and their interactions from which the emergent properties of the system derive. These elements must represent "handles" on the environment which can be measured easily and are sensitive enough to reflect the environmental impact of the Aubrey Reservoir Project.

The Environmental Evaluation System (EES) developed by Battelle-Columbus (1,2) for the Bureau of Reclamation's water resource projects is an adequate system for numerical evaluation of the environmental impact of the Aubrey Reservoir Project. Essentially, the EES abstracts the environment into a hierarchical system (i.e., from general to specific) of four categories, 18 components and 78 parameters:

| | |
|--------------------------------------|-------------------------------|
| Eccology (240) | Environmental Pollution (402) |
| <u>Species and Populations (140)</u> | <u>Water Pollution (318)</u> |
| Terrestrial | (20) Basin hydrologic loss |
| (14) Browsers and grazers | (25) BOD |
| (14) Crops | (31) Dissolved oxygen |
| (14) Natural vegetation | (18) Fecal coliforms |
| (14) Pest species | (22) Inorganic carbon |
| (14) Upland game birds | (25) Inorganic nitrogen |
| | (28) Inorganic phosphate |
| Aquatic | (16) Pesticides |
| (14) Commercial fisheries | (18) pH |
| (14) Natural vegetation | (28) System flow variation |
| (14) Pest species | (28) Temperature |
| (14) Sport fish | (25) Total dissolved solids |
| (14) Waterfowl | (14) Toxic substances |
| | (20) Turbidity |

| | |
|---------------------------------------|---|
| <u>Habitats and Communities</u> (100) | <u>Air Pollution</u> (52) |
| Terrestrial | (5) Carbon monoxide |
| (12) Food web index | (5) Hydrocarbons |
| (12) Land use | (10) Nitrogen oxides |
| (12) Rare and endangered species | (12) Particulate matter |
| (14) Species diversity | (5) Photochemical oxidants |
| | (10) Sulfur oxides |
| | (5) Other |
| Aquatic | <u>Land Pollution</u> (28) |
| (12) Food web index | (14) Land use |
| (12) Rare and endangered species | (14) Soil erosion |
| (12) River characteristics | |
| (14) Species diversity | <u>Noise Pollution</u> (4) |
| <u>Ecosystems</u> | (4) Noise |
| Descriptive only | |
| Esthetics (153) | Human Interest (205) |
| <u>Land</u> (32) | <u>Educational/Scientific Packages</u> (48) |
| (6) Geologic surface material | (13) Archeological |
| (16) Relief and topographic character | (13) Ecological |
| (10) Width and alignment | (11) Geological |
| | (11) Hydrological |
| <u>Air</u> (5) | <u>Historical Packages</u> (55) |
| (3) Odor and visual | (11) Architecture and styles |
| (2) Sounds | (11) Events |
| | (11) Persons |
| <u>Water</u> (52) | (11) Religions and cultures |
| (10) Appearance of water | (11) "Western Frontier" |
| (16) Land and water interface | |
| (6) Odor and floating materials | <u>Cultures</u> (28) |
| (10) Water surface area | (14) Indians |
| (10) Wooded and geologic shoreline | (7) Other ethnic groups |
| | (7) Religious groups |
| <u>Biota</u> (24) | <u>Mood/Atmosphere</u> (37) |
| (5) Animals--domestic | (11) Awe-inspiration |
| (5) Animals--wild | (11) Isolation/solitude |
| (9) Diversity of vegetation types | (4) Mystery |
| (5) Variety within vegetation types | (11) "Oneness" with nature |

Man-made Objects (10)

(10) Man-made objects

Composition (30)

(15) Composite effect

(15) Unique composition

Life Patterns (37)

(13) Employment opportunities

(13) Housing

(11) Social interactions

The environmental parameters represent significant specific attributes of the environment which are relevant to water resource projects and collectively capture the environmental quality with and without the project. The difference between the "with" and "without" environmental quality represents the impact of the project. Since the EES was designed for the Bureau of Reclamation's water resource projects, we were contracted to use it instead of other available techniques (3, 4, 5, 6).

Since our use of the EES followed the outline presented in the Battelle-Columbus report (1), the general description of the EES and our use of it is presented only briefly here. Only that information necessary for understanding our report is discussed.

We used the EES so the total numerical environmental impact index would reflect both spatial and temporal effects of the Aubrey Reservoir Project. We systematically considered short-term or construction (the first 5 years) and long-term or use (next 15 years) effects; and upstream, site and downstream effects.

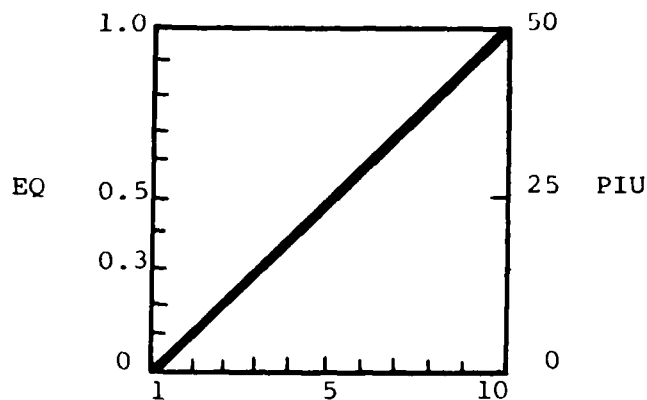
The rates of environmental, sociological, economical, cultural, demographical, etc., changes in our country make a 20-year forecast truly "long-term." Therefore, because of the levels of resolution and confidence associated with many of the Battelle-Columbus EES parameters, we conservatively restricted our long-term (use period) impact calculations to within a 20-year period of the initiation of the project. Since the project will not begin for several years, this represents a projection greater than 20 years. However, our opinion is that our impact estimates will apply to most of the EES parameters for a longer period of time associated with the "normal" life of reservoirs in this part of the country. We also anticipate that the Army Corps of Engineers will undertake or contract periodic re-evaluations of the reservoir's impact; thus, keeping abreast of changes which may not be predictable now.

A total of 1000 points was apportioned among the four categories according to the weighting procedure developed by

Battelle-Columbus and explained in their report (1). The points assigned to each category were then apportioned among their components and parameters according to the same weighting procedure. The values assigned to the environmental parameters are referred to as Parameter Importance Units (PIU) and reflect the relative importance of each parameter. Numbers in parentheses in the above list represent the points assigned to categories, components and parameters. Because the weights given to the parameters by Battelle-Columbus (1) represent relative importance within the EES, and should not vary from project to project according to the subjective judgment of the investigating team, we retained their weights. In this way we maintained objectivity during our analysis and arrived at a numerical environmental impact index for the Aubrey Reservoir Project which can be easily replicated and directly compared with impacts of other projects evaluated with the EES, especially those in the Trinity River Basin.

All environmental parameters were transformed into commensurate units according to the procedure described in the Battelle-Columbus Report (1). This transformation followed three basic steps:

1. Weight parameters according to their relative importance in PIU's.
2. Transform all parameter estimates (based on field measurements and/or literature data) into corresponding units of Environmental Quality (EQ = 0 to 1). This scaling procedure of each parameter into a 0-1 range (0 = extremely poor quality; 1 = extremely high quality and corresponds to the maximum PIU assigned to a parameter) provides a common base with which all parameters, regardless of their PIU's, can be directly compared; and impacts can be expressed in commensurate units. The transformation of a parameter estimate or measurement into EQ is achieved through use of a value function which relates the various levels of parameter estimates or measurements to appropriate EQ levels. Fig. 1 is an example of a value function. We used the value functions developed by Battelle-Columbus (1) in our study.



Actual Parameter Measurement
In Absolute Units

Fig. 1. Example of a Linear Value Function.
Modified from the Battelle-Columbus Report (1).

From the figure it can be seen that a parameter with an absolute measurement value of 5 has an EQ of 0.5 and a PIU of 25 ($EQ \times PIU_{max}$).

3. Obtain commensurate units or Environmental Impact Units (EIU), which are calculated as:

$$EIU = EQ \times PIU_{max}$$

Environmental impacts are measured in EIU's. For example, assume that the measurement of 5 represents the present status of the parameter (Fig. 1) without the project and the predicted measurement of the parameter with the project is 3. The impact of the project on the parameter in EIU's is calculated as:

$$\begin{aligned} \text{Project Impact} &= EIU \text{ (with project)} - EIU \text{ (without)} \\ &= (0.3 \times 50) - (0.5 \times 50) \\ &= (15) - (25) \\ &= -10 \end{aligned}$$

The percent EQ change resulting from the project is calculated as:

$$\% \text{ EQ change} = \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100$$

or, a change of

$$\frac{0.3 - 0.5}{0.5} \times 100 = -40\%$$

To capture the spatial and temporal aspects of the Aubrey Reservoir Project's impact on the parameters, we used two time frames (construction or short term = 5 years; and operation, use or long-term = the following 15 years) and three spatial frames (upstream, site and downstream) for the "with" project EIU evaluation. The "without" project EIU's were evaluated using a single time frame and the three spatial frames. Calculation of an impact index (in EIU's) which contains spatial and temporal elements required use of a worksheet-matrix. Fig. 2 is an example of a worksheet-matrix used to include the spatial and temporal components into a single impact index for a given parameter.

| Spatial Temporal | Upstream RI = 0.25 | Site RI = 0.50 | Downstream RI = 0.25 |
|---|-----------------------|-------------------|-------------------------|
| | | | |
| "Without" RI = 1.0 | 10 | 10 | 10 |
| "With" Construction Period RI = 0.25 | 5 | 2 | 5 |
| "With" Use Period RI = 0.75 | 5 | 5 | 5 |

Fig. 2. Worksheet-matrix used to include spatial and temporal components in an index of the project's impact on a given parameter. RI = relative importance of each frame. RI's are assigned on the basis of professional judgment of the evaluator to the spatial and temporal frames. Numbers in each cell represent means of actual parameter measurements, estimates or predictions. Modified from Battelle-Columbus Report (1).

The worksheet data must be transformed into Environmental Quality Units (EQ) for each parameter for the "with" and "without" project considerations. This is achieved in four basic steps:

1. Assign relative importance (RI) to each spatial and temporal frame according to professional judgment of the evaluator.
2. Multiply this RI factor by the actual parameter measurement in each cell.
3. Sum the products of RI and the actual parameter measurements in each cell for the "with" and "without" values. This results in an estimate of the parameter value which is weighted according to the relative importance of each spatial-temporal frame.

$$\text{Parameter value} = \sum_{i=1}^n \sum_{j=1}^m C_{ij} X_{ij}$$

("with" or "without")

where

- i = Spatial index
 - j = Temporal index
 - C_{ij} = Importance of cell ij
 - X_{ij} = Measurement of cell ij
 - n = Number of spatial areas considered
 - m = Number of time factors considered
4. Determine the EQ of the weighted parameter estimates for with and without the project from a value function graph (these graphs are found as Figs. 1-68 in Appendix A).

The environmental impact on a parameter in EIU is calculated as:

$$\text{EIU} = (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}),$$

where EQ's are derived according to the preceding four steps. The following is an example using data in the previous worksheet (Fig. 2) and the value function graph (Fig. 1) to calculate the environmental impact on a parameter:

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0.25 \times 10) + (0.50 \times 10) + \\ \text{Project} &\quad (0.25 \times 10)) = 10 \end{aligned}$$

Weighted Parameter
 Estimate With = $0.25 ((0.25 \times 8) + (0.50 \times 8) +$
 Project-Construction $(0.25 \times 8)) = 2$
 Period

Weighted Parameter
 Estimate With = $0.75 ((0.25 \times 4) + (0.50 \times 4) +$
 Project-Use Period $(0.25 \times 4)) = 3$

Total weighted parameter estimate with project = 5.0

For this example the environmental quality (EQ) determined from Fig. 1 is:

"Without" EQ = 1.0
 "With" EQ = 0.5

Therefore, the environmental impact (EIU) on the parameter is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (50 \times 0.5) - (50 \times 1.0) \\ &= -25 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"with" EQ} - \text{"without" EQ}}{\text{"without" EQ}} \times 100 \\ &= \frac{0.5 - 1.0}{1.0} \times 100 \\ &= \frac{-0.5}{1.0} \times 100 \\ &= -50\% \end{aligned}$$

Therefore, to obtain the total numerical impact index for the entire project it is necessary to determine the EIU for each specific parameter and then sum over all 78 parameters. The Environmental Impact Index in EIU's is determined by using the following equation:

$$\text{EIU} = \sum_{i=1}^{78} w_i \text{EQ}_i(\text{with}) - \sum_{i=1}^{78} w_i \text{EQ}_i(\text{without}),$$

where

- i = parameter index
- w_i = relative importance of i th parameter in PIU
- EQ_i = environmental quality coefficient of i th parameter obtained from value function graph.

In general, a negative (-) change indicates an adverse environmental impact and a positive (+) change indicates a beneficial impact.

The EES uses "Red Flags" to point out extremely fragile environmental elements (i.e., those likely to be significantly changed adversely by a project) and/or those for which adequate quantitative data are unavailable at the writing of the Environmental Impact Statement. "Red Flags" are used to indicate parameters which require further detailed study and/or should be given special consideration in the planning and modification of the project. We used "Red Flags" to indicate fragile elements and those for which detailed quantitative data were not available as a result of the time limitations on this study. "Red Flags" should be seriously considered during the planning, construction and use phases of the Aubrey Reservoir Project.

Four rules are used to determine if a negative change in a parameter constitutes a "Red Flag" and the type of flag that should be used. Each of these rules is based on a change in the parameter's environmental quality (EQ) as measured by the extent of difference between the "with" and "without" evaluations. Recall that the EQ of a parameter is determined from a value function graph.

For Ecology Parameters:

Rule 1 Minor Flag: The negative change in percent between the "with" and "without" EQ is between 5 and 10%*.

Rule 2 Major Flag: The negative change in percent between the "with" and "without" EQ is greater than 10%.

For all other parameters:

Rule 3 Minor Flag: The negative change between the "with" and "without" EQ is greater than or equal to 0.1 in absolute value. This change is less than 30%.

Rule 4 Major Flag: The negative change between the "with" and "without" EQ is greater than or equal to 0.1 in absolute value. This change is greater than or equal to 30%.

$$*Percent = \frac{\text{"with" EQ} - \text{"without" EQ}}{\text{"without" EQ}} \times 100$$

Since these rules were determined by Battelle-Columbus (1) on the basis of one field test with small sample sizes, each negative EQ change should be considered individually as to whether it merits a "Red Flag." However, in most cases we pointed out where the system was perhaps too sensitive in calling for "Red Flags."

Use and Results of the Environmental Evaluation System

The following four sections (Ecology, Environmental Pollution, Esthetics and Human Interest) contain the results and discussion of our use of the Battelle-Columbus environmental Evaluation System (EES) to assess the environmental impact of the Aubrey Reservoir Project. The descriptive narrative for each category and component is similar to that found in the Battelle-Columbus Report. The narratives and methods for calculating impacts on parameters vary in depth according to their respective importance in the EES. Those parameters which we thought were of the greatest significance are treated in the most detail.

Ecology

This category contains three components and 18 parameters. These were selected by Battelle-Columbus for the EES because they were attributes of contemporary ecological systems which would reflect changes in the quality of those systems resulting from water resource projects and could be measured or estimated from existing data within a reasonable amount of time and cost. Since most contemporary ecological systems have been produced by interactions among man, domestic and cultivated and wild biota, and the habitat, the parameters selected for the EES must be attributes which reflect these interactions. They should provide means to determine the state of ecological systems with respect to:

1. Stability or balance and productivity (ability to regenerate renewable resources and supply unrenewable resources).
2. Quality in regard to man and his use of ecological systems.
3. Sensitive areas such as habitats or species of sport, commercial and educational interests.

Species and Population

Because many ecological analyses have been and are concerned with species and populations, information concerning them is often available. Since species and their populations are sensitive to environmental changes, they can be used to detect subtle changes which may eventually result in major impacts upon the system. The types of species included in the EES are those which are either good indicators of a healthy natural ecological system or of commercial, recreational or economic value to man, or both.

Browsers and Grazers

A reduction in browsers and grazers on range land represents a reduction of a dominant animal in ecosystems of the western U. S. On the proposed Aubrey Reservoir site, domestic cattle are the only grazers that occur in significant numbers, and available grazing land will definitely be destroyed by inundation. To calculate the total impact of the reservoir on these lands and the parameter Browsers and Grazers, an estimate of the quality of the area as grazing land must be made.

The ultimate capacity of the land for grazing is dependent upon the plant production of the area. In practice, 50 to 60% of the annual plant production should be consumed for the ultimate in animal production. This is illustrated in the graph of the value function for Browsers and Grazers (Fig. 1). It is easily seen that any increase in land use over the 40 to 50% limit reduces the quality and stability of the ecosystem rapidly to 0. At values less than 40 to 50%, optimum use of the land is not being made.

To arrive at the value function, the following are required:

1. The number of grazers occurring on the grazing land.
2. Conversion of the number of grazers to a conventional agricultural unit (AU) of food consumption, i. e., 9600 lb/cow/acre/year.
3. The number of acres of grazing land.
4. The annual production of grazing land in lb/acre/year.

These data are used to calculate the number of acres needed to support one AU according to the following:

$$\text{Acres of Habitat/AU} = \frac{\text{AU}}{\text{Net Plant Production}}$$

Next, by dividing the number of acres of habitat by the number of acres required to support one AU, a calculation of the ultimate capacity in AU is made as follows:

$$\text{Ultimate Capacity} = \frac{\text{Acres of Habitat}}{\text{Acres of Habitat/AU}}$$

Calculation of the above is shown below. Data represent average measurements of plant production and were provided by the Texas A & M Experiment Station, Denton, Texas. The number of cattle on the area is an estimate from the Denton County Agricultural Agent.

No change in grazing patterns is expected either upstream or downstream from the reservoir site. In calculating change in environmental quality, these areas are given relative importance values of 0. During construction it is estimated that 25% of the available land will be unavailable for grazing. In addition, the construction phase will have a relative importance in reducing grazing of 0.25. The use phase will further remove all of the cattle on the reservoir site.

As calculated below, of the possible 14 Parameter Importance Units, a total of 11.76 are currently calculated without the project. A loss of only 2.80 PIU should occur during construction, while the remainder, 8.96, will be entirely lost by inundation.

A consideration of this "Major Red Flag" is appropriate. From examination of the area, it is apparent that many major ecological features, species diversity, food web index, game, etc., have been diminished through grazing. This is not to say that the land is overgrazed, but that too much of the reservoir site is currently being grazed to capacity. There are no remaining areas that can be considered natural that would balance ecologically against grazers. An area so depauperate in natural flora and fauna cannot be considered to be enhanced by grazers, and the "Major Red Flag" erected by a loss in these organisms is ecologically questionable here.

$$\begin{aligned}
 \text{Acres of Habitat/AU} &= \frac{9600 \text{ lb/acre/year}}{1800 \text{ lb/acre/year}} \\
 &= 5.33 \\
 \text{Ultimate Capacity} &= \frac{26,635 \text{ acres}}{5.33 \text{ acre/AU}} \\
 &= 4622 \text{ AU}
 \end{aligned}$$

The parameter estimate to be used in formulating the value function from Fig. 1 is calculated as follows:

$$\begin{aligned}
 \text{Parameter Estimate} &= \frac{\text{Total AU on the Area}}{\text{Ultimate Capacity of the Area in All}} \\
 &= \frac{2000 \text{ AU}}{4622 \text{ AU}} \\
 &= 0.43
 \end{aligned}$$

$$\begin{aligned}
 \text{Weighted Parameter Estimate Without Project} &= 1.0 ((0 \times 0.43) + (1.0 \times 0.43) + (0 \times 0.43)) \\
 &= 0.43
 \end{aligned}$$

$$\begin{aligned}
 \text{Weighted Parameter Estimate With Project-Construction} &= 0.25 ((0 \times 0.43) + (1.0 \times 0.43) + (0 \times 0.43)) \\
 &= 0.11
 \end{aligned}$$

$$\begin{aligned}
 \text{Weighted Parameter Estimate With Project-Use} &= 0.75 ((0 \times 0.43) + (1.0 \times 0) + (0 \times 0.43)) \\
 &= 0
 \end{aligned}$$

Total weighted estimate with project = 0.11

For this parameter the EQ determined from Fig. 1 is:

$$\begin{aligned}
 \text{"Without" EQ} &= 0.84 \\
 \text{"With" EQ} &= 0.20
 \end{aligned}$$

Therefore, the environmental impact on Browsers and Grazers is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (14 \times 0.20) - (14 \times 0.84) \\
 &= (2.80) - (11.76) \\
 &= -8.96
 \end{aligned}$$

$$\begin{aligned}
 \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\
 &= \frac{0.20 - 0.84}{0.84} \times 100 \\
 &= \frac{0.64}{0.84} \times 100 \\
 &= -76\% \quad \text{which is a "Major Red Flag."}
 \end{aligned}$$

Crops

Agriculture involves the ecological management of communities of economic plants. The Battelle EES classifies types of farming as Dryland, Irrigated and Pasture.

The importance of this parameter revolves around total loss or increase in production as pounds of forage or grain or grass per acre per year brought about by the engineering project. If arable land is lost, the loss may be detrimental depending upon the extent and its fertility. If irrigation results from the project, then the increase in arable land and degree of increased production may be beneficial.

Extent of the farming types, dry land and pasture (irrigated being absent) was determined by grid intercepts in acres from aerial photos of the project site. All dry land fields were confirmed by reconnaissance since these fields are being converted yearly to Bermuda pasture or abandoned to old field pasture.

Parameter measures depended not only on extent but also on productivity. To assess productivity the following modifier scale was used:

| <u>Modifier Value</u> | <u>Production</u> |
|-----------------------|-------------------|
| 1.0 | 8000 lb/acre/year |
| 0.75 | 4000 lb/acre/year |
| 0.50 | 2000 lb/acre/year |
| 0.25 | 1000 lb/acre/year |
| 0 | 0 lb/acre/year |

Production figures were obtained from the records of the Texas A & M Agricultural Substation at Denton for the site area.

Sorghum, some peanut and very little cotton (1/3 bale/acre) yields averaged 800 lb/acre/yr for 1970 and 1971. The two types of pasture averaged 1,800 lb/acre/yr for the same period. It is expected that grass yields will increase as more fields are sprigged with coastal Bermuda.

The grid intercept results are listed below as raw acres and are weighted productivity:

| <u>Type</u> | <u>Acreage</u> | <u>Weighted Productivity Value</u> |
|-------------|----------------|--|
| Dryland | 3,861 x 0.20 | 722 |
| Pasture | 26,635 x 0.40 | 10,654 |

Total weighted parameter calculations are inconsequential since with project RI's and acreages would equal zero with inundation. Spatial productivity is the same above and below the site; thus their RI's equal 0.33, so that "without" project totals are equivalent to site weighted productivity.

Conversion of weighted productivity for EQ determinations followed as:

$$\begin{aligned}
 \text{Parameter Estimate} &= \frac{\text{Total Productivity Weighted Acreage}}{\text{Total Arable Acreage}} \times 100 \\
 &= \frac{722 + 10,654}{30,496} \\
 &= 37\% \quad \text{without the project.}
 \end{aligned}$$

Since inundation with the project will reduce cropland acreage to zero, the parameter estimate with the project is 0%. For this parameter the EQ determined from Fig. 2 is:

$$\begin{aligned}
 \text{"Without" EQ} &= 0.35 \\
 \text{"With" EQ} &= 0
 \end{aligned}$$

Therefore, the environmental impact on Crops is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (14 \times 0) - (15 \times 0.38) \\
 &= (0) - (5.7) \\
 &= -5.7
 \end{aligned}$$

$$\begin{aligned}
 \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\
 &= \frac{0 - 0.38}{0.38} \times 100
 \end{aligned}$$

= -100% which is a "Major Red Flag."

Natural Vegetation

Natural terrestrial vegetation includes major physiognomic communities in a defined area, each with its characteristic species, boundaries, and internal structure, and which are excluded from hydric habitats or disappear when the substrate becomes saturated for several growing seasons.

The importance of this parameter revolves around appreciable alteration of these communities as to their present extent and productivity with implementation of the project.

Natural vegetation for productivity purposes was divided into forest and old field pasture. Their combined extent was designated as non-arable acreage in contrast to cultivated acreage.

Areas of the two types were determined with intercept grids from aerial photos with recent old field sites being confirmed in the field since some of them appeared as cultivated fields in the photos.

Parameter measure depended not only on acreage but also on a productivity modifier. Modifier values used are after the data of Westlake (7).

| <u>Modifier</u> | <u>Value</u> | <u>Community</u> | <u>Productivity*</u> |
|-----------------|--------------|------------------|----------------------|
| 1.0 | Tropical | Sugar Cane | 36 tons/acre |
| 0.33 | Old Field | Temp. Grassland | 13 tons/acre |
| 0.17 | Upland | Temp. Forest | 7 tons/acre |
| 0.0 | | | 0 tons/acre |

*Annual mean ash free dry weight.

NB: 36 tons/acre is here considered maximum possible productivity.

These acreages were modified and converted to a percentage as follows:

$$\text{Parameter Estimate} = \frac{\sum_{i=1}^N (\text{Acres of Vegetation}_i \text{ Type} \times K)}{\text{Total Nonarable Land}} \times 100$$

N = Number of categories

K = Weighted Productivity

$$\begin{aligned}
 \text{Parameter Estimate} &= \frac{(4,554 \times 0.17) + (26,635 \times 0.33)}{31,189} \times 100 \\
 &= \frac{774 + 8,789}{31,189} \times 100 \\
 &= 31\%
 \end{aligned}$$

Spatial RI values were set at 0 for above and below the site areas as the development of the project would leave little influence on the vegetational productivity of these areas. Likewise, the time relative importance values could be and were set at 0 since inundated land has no terrestrial vegetation.

Input of the data and considerations into the worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of -4.34 EIU on Natural Terrestrial Vegetation.

Weighted Parameter

Measurement Without = $1.0 ((0 \times 0) + (1 \times 31) + (0 \times 0)) = 31\%$
Project

Both With Project Parameter Estimates = 0.

For this parameter the EQ determined from Fig. 3 is:

"Without" EQ = 0.31
"With" EQ = 0

Therefore, the environmental impact on Natural Terrestrial Vegetation is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (14 \times 0) - (14 \times 0.31) \\
 &= (0) - (4.34) \\
 &= -4.34
 \end{aligned}$$

$$\begin{aligned}
 \% \text{ EQ change} &= \frac{\text{EQ}_{\text{with}} - \text{EQ}_{\text{without}}}{\text{EQ}_{\text{without}}} \times 100 \\
 &= \frac{0 - 0.31}{0.31} \times 100 \\
 &= -100\% \quad \text{which is a "Major Red Flag."}
 \end{aligned}$$

Terrestrial Pest Species

Terrestrial pest species include plant and animal species annoying or harmful to man or his crops, livestock, or game animals. Data are basically qualitative, and are based on knowledge of area botanists and zoologists, familiar with recent past infestations or outbreaks.

Four categories, weeds, plant disease species, animal disease species and carriers, and pests, are recognized and are given equal weights of 0.25. The parameter estimate also includes K, a distribution modifier, where 1.0 = Widespread, 0.67 = Intermediate, 0.33 = Restricted and 0 = Absent.

Some 62 weed species of widespread distribution, superabundance, and perpetuation by overgrazing occur in the area. These species comprise most of the natural vegetation, and mark the site as depauperate, vegetationally. The distribution modifier (K) was therefore determined as 1.0. Due to the lack of recent past serious disease outbreaks, both plant and animal disease species were assigned a K value of 0.33 (Restricted).

Terrestrial pest species include ticks, in which there was an outbreak in Spring of 1972, chiggers, stable flies and horn flies (associated with livestock) and two families of bot flies, Oestridae and Cuterebridae. These species are seasonal, but constitute an annoying element in the area, for which K = 0.67 (Intermediate) was assigned.

Inundation will have no effect on the above pests upstream and downstream, so all the spatial RI of 1.0 was assigned to the site area. Inundation will eliminate these pests on the immediate site area, and generally reduce them on the shore border, due to recreational development, so the total RI weight of 1.0 for the time element is given to the construction phase.

According to these considerations, and the parameter estimate formula:

$$\sum_{i=1}^N (\text{category weight}_i \times K) \times 100,$$

where N = number of categories; K = distribution modifier.

The present weighted percent was calculated as:

$$\begin{aligned}\text{Weeds} &= 0.25 \times 1.0 = 0.25 \\ \text{Plant disease species} &= 0.25 \times 0.33 = 0.08 \\ \text{Animal disease species} &= 0.25 \times 0.33 = 0.08 \\ \text{Pest species} &= 0.25 \times 0.67 = \underline{0.17} \\ &0.58 \times 100 = 58\%\end{aligned}$$

Obviously, inundation will greatly reduce the distribution of terrestrial pests at the site area (taken here to include both the reservoir basin and the shore border). Input of these values and considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +4.62 EIU on Terrestrial Pest Species.

Weighted Parameter

Measurement Without = $1.0 ((0 \times 58) + (1.0 \times 58) + (0 \times 58)) = 58$
Project

Weighted Parameter

Estimate With = $1.0 ((0 \times 58) + (1.0 \times 25) + (0 \times 58)) = 25$
Project-Construction

Weighted Parameter

Estimate With = 0
Project-Use

Total weighted estimate with project = 25

For this parameter, the EQ determined from Fig. 4 is:

"Without" EQ = 0.42

"With" EQ = 0.75

Therefore, the environmental impact on Terrestrial Pest Species is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.75) - (14 \times 0.42) \\ &= (10.5) - (5.88) \\ &= +4.62\end{aligned}$$

Upland Game Birds

Upland game birds provide recreation in the form of hunting and, in most cases, a food source for man. The numbers of game birds in an area provide an estimate of productivity of the region and are an indicator of environmental quality.

The only game birds occurring on the proposed Aubrey Reservoir site are quail and mourning doves, both present in only small numbers. No records of the annual harvest on the proposed site are available for recent years. Texas Fish and Game Officials report hunter success to be poor, no more than 25% of the maximum possible (100%). Available habitat is lacking due to grazing, and only 25% of the total area is habitat for upland game birds.

The parameter estimate is calculated using the following formula:

$$\text{Parameter Estimate} = \frac{\text{Area Inhabited} \times K}{\text{Maximum Habitat Area}} \times 100$$

The value for K represents a modifier using a ratio of the most recent harvest (0.25) to the maximum harvest recorded (1.00) or 0.25/1.00. The areas upstream and downstream from the site are not considered to be affected for upland game birds, and the RI values of these areas are 0. Disturbance during the construction phase has only about 0.25 of the RI, whereas inundation has 0.75 in reduction of upland game. Furthermore, it is estimated that construction will destroy 25% of current upland game habitat and inundation will completely remove all habitat (25,050 acres or area of the reservoir at the upper guide contour).

As calculated below, the EIU without the reservoir is 0.062, and the EQ with project is 0.015, resulting in a net loss with construction of 0.66 of a possible 14 Parameter Importance Units. It is apparent that construction of the reservoir will have little effect on the already depauperate upland game habitat in the area, and although the negative change in EQ is about 76%, a "Major Red Flag" exaggerates the impact; the "without" EQ is quite low. It is suggested that an area be set aside around the reservoir to restore upland game habitat to a level greater than currently exists.

$$\text{Parameter Estimate} = \frac{8512 \times \frac{0.25}{1.00}}{35,050} \times 100$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Measurement Without Project} &= 1.0 ((0 \times 6.2) + (1.0 \times 6.2) + (0 \times 6.2)) \\ &= 6.2\% \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With Project-Construction} &= 0.25 ((0 \times 6.2) + (1.0 \times 6.2) + (0 \times 6.2)) \\ &= 1.5\% \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With Project-Use} &= 0.75 ((0 \times 6.2) + (1.0 \times 0) + (0 \times 6.2)) \\ &= 0\% \end{aligned}$$

Total weighted estimate with project = 1.55%

For this parameter the EQ determined from Fig. 5 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.062 \\ \text{"With" EQ} &= 0.0155 \end{aligned}$$

Therefore, the environmental impact on Upland Game Birds is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.0155) - (14 \times 0.062) \\ &= (0.21) - (0.87) \\ &= -0.66 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.0155 - 0.062}{0.062} \times 100 \\ &= -75\% \quad \text{which is a "Major Red Flag."} \end{aligned}$$

Aquatic Species and Populations

Commercial Fisheries

Freshwater fish production has made a substantial contribution to human nutrition and to commerce over the years. The annual catch of freshwater fish by contract commercial fishermen in Texas amounts to approximately 930,000 lbs per year with an estimated value of \$111,600 (8). Additional fish are caught by fishermen who hold a \$3.00 commercial fisherman's license. The extent of the catch of these fishermen is unknown, but it is probably at least equal to that of the contract fishermen. While the contract fishermen market only buffalo, gar, drum, and other rough fish, the commercial fishermen are allowed to market catfish in addition to the rough fish. This industry is small, but it provides, for those who engage in it an independent and satisfying life style which is in itself probably as important as the economic worth of the catch. Any effect of the project on commercial fisheries will affect commercial fishermen directly and will also serve as an indicator of potential changes in other aspects of the environment.

In assessing the impact of the proposed reservoir on the commercial fisheries of the area, we assembled three sets of data: 1) a list of commercial fish species present in the area, 2) an estimate of the present maximum sustained annual yield, and 3) an estimate of the potential maximum sustained annual yield of commercial fish after the reservoir is completed.

Following the Battelle EES, we assumed that a positive linear relationship exists between the weighted percentage of the area available to commercial fish species and the EQ value. This means that maximum environmental quality (EQ = 1.0) is achieved when the entire project is covered with water suitable for fish. The "without" project value is determined by measuring the current percentage of the project area that is covered by natural streams and lakes together with man-made ponds and reservoirs.

In calculating the "without" project EQ value we divided the project area into three parts: 1) the entire watershed of the reservoir above the actual reservoir site (RI = 0.10), 2) the reservoir site itself (RI = 0.80), and 3) the 10.5 miles of Elm Fork of the Trinity River between the dam site and the upper end of Garza-Little Elm Reservoir to the south (RI = 0.10).

The surface area of streams in the upstream area was determined by multiplying the mean width of the streams, as measured in the field, by the length of the streams obtained from U. S. Geological Survey topographic maps. Only streams which generally flow throughout the year were measured. By measuring the areas on the topographic maps we determined that the upstream drainage of the reservoir will include approximately 407,830 acres. About 0.28% of the total area or 1145 acres is covered by streams. The total surface area covered by ponds, stock tanks and reservoirs is approximately 0.14% or 574 acres.

The area of the proposed Aubrey Reservoir at the top of the conservation pool is estimated to be 25,300 acres. Approximately 70.8 acres of this total is presently covered by the surface of streams in the area, principally Elm Fork (33.3 acres), Isle du Bois Creek (20.4 acres), Buck Creek (4.7 acres), Spring Creek (3.6 acres), and six other creeks of less than 3.0 acres. Stock tanks and small reservoirs within the site presently cover another 35.3 acres.

Elm Ford of the Trinity River extends approximately 10.5 miles below the proposed dam site before running into Garza-Little Elm Reservoir. The mean width of the stream in this area is 20.1 feet with a total surface area of 25.4 acres. Stock tanks and reservoirs in the downstream area were not considered significant in assessing the effects of the reservoir on commercial fisheries.

In the Battelle EES the parameter estimate of "percent of total acreage" on the abscissa of the value function graph (Fig. 6) is actually determined by the following equation:

$$\text{Parameter Estimate} = \left(\frac{\text{Area inhabited} \times K}{\text{Maximum habitat area}} \right) \times 100$$

In this equation K is a quality modifier based on the dollar value of the annual commercial catch. The value of the catch is weighted on a scale of 0 to 1 according to the following schedule:

| | | |
|------|---|-------------|
| 1.0 | - | \$1,000,000 |
| 0.67 | - | 100,000 |
| 0.33 | - | 10,000 |
| 0 | - | 1,000 |

The threshold value for an economically feasible fishery is approximately \$1,000, hence any value less than this is given

a quality value of 0.

In a comprehensive review of the commercial harvest of fish from reservoirs in the U. S., Jenkins (9) reported a mean annual harvest of 10.2 lbs of undressed fish per surface acre. Most of the reservoirs included in his survey were located in the mid-south states of Tennessee, Oklahoma, the Carolinas, Texas, etc. Wenger (10) reported that the mean annual harvest of commercial fishes in Hardin, Jefferson, and Orange Counties, Texas, was 12 lbs/acre/year. For the purposes of this study it was assumed that the expected annual harvest of commercial species would be 12 lbs/acre of surface area in the proposed reservoir.

Because streams receive large inputs of energy from surrounding terrestrial ecosystems, they are usually more productive than lentic waters in comparable areas. Therefore, we estimated that the annual harvest from streams in the area could reasonably be expected to be higher than that from reservoirs. No harvest data from streams in the area could be found, so we estimated that the commercial harvest would be 18 lbs/acre/year. The time allotted for completing the study (3 months) did not allow for an actual measurement of harvest over an entire year.

The determination of monetary values to be placed on harvested fish is complicated by many factors associated with cost of fishing, market access, consumer preferences, species composition of the catch, etc. From our fisheries survey of the area (see element report on Fishes), reports of fish netted from Garza-Little Elm Reservoir (11, 12) and the published results of commercial fishing in other reservoirs in Texas (8, 10), we concluded that the most important species of fish likely to occur in the reservoir would be: smallmouth buffalo, channel catfish, flathead catfish, carp, gar, suckers, drum, and carpsuckers. Wenger (10) reported that the average market value for undressed fish of these species in Texas was \$0.12/lb. Although catfish bring \$0.30-0.35/lb, they are not usually caught in large amounts relative to the catch of buffalo and other rough fish. In fact, contract commercial fishermen in Texas are not allowed to keep catfish caught in gill and trammel nets.

Therefore, in estimating the monetary value of the catch we applied the average value of \$0.12/lb. It was estimated that the total value of the potential annual harvest of commercial species from the entire area without the project would be \$3558 (Table 2).

Table 2. Maximum potential harvest of commercial fish species from the upstream, reservoir site, and downstream areas of the proposed Aubrey Reservoir, expressed as lbs/year and dollar value of the harvest.

| Data | Upstream | Site | Downstream |
|-----------------|----------|----------|------------|
| Without project | | | |
| annual harvest | 27,489 | 1968 | 457 |
| cash value | \$3,299 | \$204 | \$55 |
| With project | | | |
| annual harvest | 27,489 | 303,600 | 457 |
| cash value | \$3,299 | \$36,432 | \$55 |

When this value was broken down into the upstream, reservoir site, and downstream areas, its quality modifiers (K) were 0.10, 0.03, and 0.01 for the construction years, and 0.11, 0.05, and 0.01 for the use period (15 years after construction) respectively. The quality modifiers increase slightly in the use period (20 years) at all areas because in the next two decades the human population of the U. S. will continue to grow and the demand for animal protein may increase the relative value of freshwater fish products. Also, it is expected that new ponds and small reservoirs will be built in the area, and these would provide a small additional area for fishing.

While the harvest of fish from the upstream and downstream areas will remain nearly the same following construction of the dam, the harvest of fish from the inundated reservoir site will, or course, increase significantly. The total potential harvest is estimated to have a value of \$39,786 (Table 2). When broken down into areas, this figure yielded quality modifiers of 0.10, 0.01, and 0.01 for the upstream, reservoir site, and downstream areas respectively in construction years. For the use period the modifier values were 0.11, 0.41, and 0.02 respectively. Input of these measurement data in the worksheet-matrix and calculations below yielded an impact index of +4.536 on Commercial Fisheries.

Weighted Parameter

Estimate Without Project = $0.25 ((0.10 \times 0.043) + (0.80 \times 0.012) + (0.10 \times 0.001)) +$

$$0.75 ((0.10 \times 0.054) + (0.80 \times 0.024) + (0.10 \times 0.001)) \\ = 0.0220\%$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.10 ((0.10 \times 0.042) + (0.80 \times 0.008) + \\ \text{Project-Construction} &\quad (0.10 \times 0.001)) \\ &= 0.00107\% \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.90 ((0.10 \times 0.054) + (0.80 \times 45) + \\ \text{Project-Use} &\quad (0.10 \times 0.002)) \\ &= 32.405\% \end{aligned}$$

Total weighted parameter estimate with project = 0.3242.

For this parameter the EQ determined from Fig. 6 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.00022 \\ \text{"With" EQ} &= 0.3242 \end{aligned}$$

Therefore, the environmental impact on Commercial Fisheries is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.3242) - (14 \times 0.0002) \\ &= (4.539) - (0.0028) \\ &= +4.536 \end{aligned}$$

Natural Aquatic Vegetation

Natural vegetation within a defined area may be characterized by the major physiognomic communities present, each possessing boundaries, an internal structure and specific components. Aquatic communities are those whose species are adapted to such hydric habitats as swamps, ponds, impoundments, streams and seeps.

A real alteration of aquatic vegetation by project development could be important in one or both of two ways: 1) the interruption or enhancement of food chains in site, above-project and below-project areas or 2) a substantial increase or decrease in amount and kind of aquatic habitat.

With reference to the latter possibility, we might note that any increase on the Woodbine would be significant. Seeps and swamps fed by springs that support permanent aquatic vegetational communities are practically non-existent, as is the wildlife dependent on such vegetation. Streams are intermittent, scoured by seasonal floods so that flow-regulated impoundments offer the only possibility for extensive development. Even so, this depends upon lacustrine deposition in the shallow portions of the impoundment. As storage capacity is lost, aquatic community development is enhanced, and certain beneficial biotal shifts take place.

Parameter estimates were made in acres from aerial photos, topographic charts and field reconnaissance and the vegetation therein weighted according to quality categories as defined by Battelle in their EES report (1) as shown in Tables 3 and 4.

Table 3 . The Quality Categories used for lakes, streams, and estuaries and their weights

| Quality Category | Description | Weight |
|------------------|--|--------|
| A | High plant productivity, good water quality, good year-round water supply, diverse food web, large fish population | 1.0 |
| B | Moderate-to-high plant productivity, good water quality, some water level fluctuation, diverse food web, moderate-to-large fish population | 0.75 |
| C | Moderate plant productivity, fair water quality, water level fluctuation, simplified food web, moderate fish population | 0.50 |
| D | Low plant productivity, poor water quality, water level fluctuation, simplified food web, small fish population | 0.25 |
| E | Very low to zero plant productivity | 0 |

Table 4 . Water Quality Categories used for wetlands and their weights.

| Quality Category | Description | Weight |
|------------------|--|--------|
| A | High plant productivity, good water supply, year-round waterfowl usage, good waterfowl production, good hunting, good migrant bird usage | 1.0 |
| B | Moderate plant productivity, fluctuating water supply, some year-round waterfowl usage, limited waterfowl production, limited hunting, good migrant bird usage | 0.67 |
| C | Low plant productivity, intermittent water supply, limited waterfowl usage, no waterfowl production, poor hunting, limited migrant bird usage | 0.33 |

The raw and qualified acreages were:

| <u>Field Estimates</u> | <u>Quality - Modified</u> |
|------------------------|---------------------------|
| Without project 464a | 0.15c x 465 = 70 |
| With project 11,510b | 0.50d x 11,510 = 5,755 |

- a. The total acreage within the upper guide level of some 116 small farm impoundments and indicated marshes of abandoned gravel operations of which few possessed enough of a water level continuity to warrant such indicators of Water Quality Category C as Ludwigia, Typha, Leersia and Potamogeton.
- b. Adjusted as a factor between Water Quality Categories D and E for ponds.
- c. An estimate based on the wetland development in the shallow, northern portion of Lake Dallas, an impoundment just south of the site. One-third of the former acreage is now a high water table lacustrine plain.
- d. An intermediate factor between Quality Categories B and C for wetlands.

Isle du Bois and Elm Fork stream bed acreages are excluded because their quality category is E.

Spatial RI values were considered equal as the potential for the development of aquatic vegetation in streams, seeps, and farm impoundments differ little above or below the site from the site.

Time RI values were also considered equal since the opportunity for development does not change only the development which is reflected in this estimate.

Impact of the data and the above considerations into the worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of +1.04 EIU on Natural Aquatic Vegetation.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0.33 \times 70) + (0.33 \times 70) + \\ \text{Project} &\quad (0.33 \times 70)) \\ &= 70 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.50 ((0.33 \times 70) + (0.33 \times 0) + \\ \text{Project--Construction} &\quad (0.33 \times 70)) \\ &= 23 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.5 ((0.33 \times 70) + (0.33 \times 5,755) + \\ \text{Project--Use Period} &\quad (0.33 \times 70)) \\ &= 972 \end{aligned}$$

Total weighted estimate with project = 996

In order to determine environmental quality (EQ) these weighted values of acre-quality values had to be converted to percent of total unweighted acreage (Fig. 7).

$$\begin{aligned} \text{Without project \%} &= \left(\frac{70}{11,974} \right) \times 100 \\ &= 0.58\% \end{aligned}$$

$$\begin{aligned} \text{With project \%} &= \left(\frac{996}{11,974} \right) \times 100 \\ &= 8.3\% \end{aligned}$$

For this parameter the EQ determined from Fig. 7 is:

"Without" EQ = 0.006

"With" EQ = 0.08

Therefore, the environmental impact on Natural Aquatic Vegetation is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.08) - (14 \times 0.006) \\ &= (1.12) - (0.08) \\ &= +1.04 \end{aligned}$$

Aquatic Pest Species

Aquatic pest species include plant and animal species annoying to man, commercial and sport-fish, or waterfowl. Four categories, weeds, plant disease species, animal disease species and carriers and pests are recognized, and are given equal weights of 0.25.

Aquatic weeds are of little consequence in the area, and few data are available or could be obtained in the length of time allotted the study for the plant and animal disease categories. The presence of pest animal species and vectors are known on a qualitative basis. The parameter estimate is based on the weights given the four categories above, and a distribution modifier (K), where 1.0 = Widespread; 0.67 = Intermediate; 0.33 = Restricted; and 0 = Absent. The first three categories (weeds, plant disease organisms and animal disease organisms and carriers) are estimated at the restricted level, since no serious outbreaks have been known to occur in the area. Some problems with mosquito-borne western Equine Encephalomyelitis and Anaplasmosis have been manifested, but are so geographically widespread and seasonal that they are not attributable only to conditions existing in the upper Elm Fork Trinity watershed.

The present parameter estimate is based on these considerations by the following calculation:

$$\sum_{i=1}^n (\text{category weight}_i \times K) \times 100,$$

where

n = number categories; K = distribution modifier

the present weighted percent was calculated as:

| | |
|--|---|
| Weeds | = 0.25 x 0.33 x 100 = 8.25 |
| Plant disease organisms | = 0.25 x 0.33 x 100 = 8.25 |
| Animal disease organisms and carriers | = 0.25 x 0.33 x 100 = 8.25 |
| Pests and nuisance animals | = 0.25 x 0.67 x 100 = <u>16.75</u> weighted percent = 41.5 |

Due to the vagility of aquatic pest species, that are widespread in the area, no major changes should result in their populations over the next 15 years as a result of establishment of the Aubrey Reservoir. Low rainfall and variable nutrient conditions will promote esthetically undesirable or noxious algal blooms, but these already exist under these conditions in the river, and in nearly all reservoirs. No marked increase in plant or animal disease organisms or carriers are anticipated with the project.

The mosquito, Aedes sollicitans, found in the area, has been shown to disperse over 8 miles (13) and has been found up to 110 miles out over the Atlantic Ocean (14). Other mosquito species and midges in the area disperse several miles. Tabanus stratus and Tabanus sulcifrons, two horse flies in the area, are known to disperse up to 5.5 and 8.2 miles, respectively (15). Since these species breed in temporary aquatic or semi-aquatic situations in the area, and because of their flight ability, no major change in their populations should result from the impoundment. The increase in lake benthic habitat and short flight ranges will increase the number of nuisance non-biting midges (Chironomidae) in the area. However, because they are considered of relatively minor importance in this area of Texas, a minor increase in weighted percent from 42 to 48 and 50 is predicted during the construction and use phases, respectively. The slight increase from 42 to 45% for both construction and use is predicted downstream, primarily as a result of increases in buffalo gnats (Simuliidae) in the ca. first 2 miles below the dam.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact index

of the Aubrey Reservoir Project of -1.4 EIU on Aquatic Pests.

Weighted Parameter

$$\begin{aligned}\text{Measurement Without Project} &= 1.0 ((0 \times 42) + (0.8 \times 42) + (0.2 \times 42)) \\ &= 42\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With Project-Construction Period} &= 0.2 ((0 \times 42) + (0.8 \times 48) + (0.2 \times 45)) \\ &= 9.48\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With Project-Use Period} &= 0.8 ((0 \times 42) + (0.8 \times 50) + (0.2 \times 45)) \\ &= 39.2\end{aligned}$$

Total weighted estimate with project = 48.68

For this parameter the EQ determined from Fig. 8 is:

$$\text{"Without" EQ} = 0.6$$

$$\text{"With" EQ} = 0.5$$

Therefore, the environmental impact on Aquatic Pest Species is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.5) - (14 \times 0.6) \\ &= (7.0) - (8.4) \\ &= -1.4\end{aligned}$$

$$\% \text{ EQ change} = \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100$$

$$= \frac{0.5 - 0.6}{0.6} \times 100$$

$$= -16.7\% \quad \text{which is a "Major Red Flag."}$$

Sport Fish

Sport fish are an important renewable resource in Texas. In 1969 approximately 1,369,646 anglers were licensed as sport

fishermen in Texas (8). An additional large number of fishermen are not included in this group because a person fishing in his home county with certain types of gear need not purchase a license in Texas. The U.S. Fish and Wildlife Service (16) has estimated that there were about 1,800,000 freshwater anglers in Texas in 1965.

Many sport fishermen are deeply concerned about the effects of any proposed project on fishery resources, and they are usually quite willing and able to translate their concern into action through several private organizations (Izaak Walton League, Sport Fishing Institute, Trout Unlimited, National Wildlife Federation, etc.) as well as through state and federal agencies charged with the management of fishery resources. The avid fisherman may spend hundreds of dollars per year for gear, boats, motors, travel and lodging to enjoy his recreation. Sport fishermen can be expected to be extremely sensitive to any impact of the proposed Aubrey Reservoir on sport fishery resources in the area.

The value function for sport fish in the Battelle EES (Fig. 9) is assumed to be linear. The EQ increases from 0 to 1.0 with increasing percentage of total area available to fish in precisely the same manner as the value function for commercial fish. The quality modifier, however, is based upon the productivity of the sport fish populations rather than the cash value of the harvest. According to the Battelle EES the quality modifiers for sport fish vary from 0 to 1.0 after the following schedule:

| <u>Quality Modifier</u> | <u>Productivity</u> |
|-------------------------|--|
| 1.0 | high productivity, stable water supply of high quality, large and diverse fish population |
| 0.75 | moderate to high productivity, some fluctuation in water supply and quality, large fish population |
| 0.50 | moderate productivity, fair water supply and quality, moderate fish population |
| 0.25 | low productivity, poor water quality, small fish population |
| 0.00 | very low productivity, poor water quality, intermittent flows, no fish population |

In general, stream fish populations are more productive than lake, reservoir, or pond populations because of the relatively large energy inputs to stream ecosystems from the surrounding terrestrial ecosystems. It also follows that small reservoirs are usually more productive than larger reservoirs (17) because smaller reservoirs have a greater circumference-to-area ratio and a greater shallow-water to deep-water ratio.

Jenkins (9) recently surveyed the sport fish harvest of 121 U.S. reservoirs of over 500 acres. Most of the reservoirs included in his study were in the mid-south states. The average sport fish harvest in these reservoirs was 22.6 lbs/acre. For the purposes of this study we considered 22.6 lbs/acre to be the equivalent of "moderate" fish productivity. We realize that harvest or yield represents only a variable portion of total production, but productivity data is only beginning to be collected from U.S. reservoirs while harvest data is, by comparison, readily available. When a decision is to be made here and now we must use the data that are available while recommending that future studies use productivity as a more meaningful parameter.

Wenger (10) estimated an annual sport fish harvest of 23 lbs/acre for Taylors Bayou, Texas in 1965. We have therefore assumed (conservatively) that the proposed reservoir would be of moderate productivity with respect to sport fish populations. Bennett (18) has reported much higher yields in lbs/acre of fish from small ponds (less than 10 acres) in Illinois, Missouri, and Oklahoma. The range of values for sport fish harvest from these small ponds ranged from 20 to 300 lbs/acre/year with an average value of 110 lbs/acre/year. Funk (19) reviewed the harvest of sport fish from warm-water streams in the U.S. and reported a range of annual harvests of 1.4 to 45.5 lbs/acre.

In estimating the impact of the project on sport fisheries we used the same spatial and temporal divisions of the area that were used in determining the impact of commercial fisheries. The quality modifiers applied were:

| | <u>Upstream</u> | <u>Reservoir site</u> | <u>Downstream</u> |
|-----------------|-----------------|---------------------------|-------------------|
| Without project | 0.70 | 0.70 | 0.65 |
| With project | | | |
| -Construction | 0.70 | 0.25 | 0.30 |
| -Use | 0.70 | 0.60 | 0.65 |

In general, all three areas are considered to be of moderate-to-high productivity without the project because

most of the surface area is made up of very productive small ponds and somewhat less productive warm-water streams. During construction of the dam it is assumed that alterations of the channel of streams, draining of ponds, increased turbidities and runoff, and decreasing dissolved oxygen content will decrease productivity within the reservoir site and downstream. Following completion of the project we believe the reservoir itself will be of moderate productivity (K value = 0.60).

When the data were entered on the worksheet-matrix for Sport Fish, they yielded the following parameter estimates and environmental quality values:

Weighted Parameter

$$\begin{aligned} \text{Estimate Without Project} &= 0.25 ((0.10 \times 0.295) + (0.80 \times 0.293) + \\ &\quad (0.10 \times 0.081)) + \\ &\quad 0.75 ((0.10 \times 0.343) + (0.80 \times 0.332) + \\ &\quad (0.10 \times 0.081)) \\ &= 0.299\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project-Construction} &= 0.10 ((0.10 \times 0.295) + (0.80 \times 0.105) + \\ &\quad (0.10 \times 0.038)) \\ &= 0.01 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project-Use} &= 0.90 ((0.10 \times 0.343) + (0.80 \times 60) + \\ &\quad (0.10 \times 0.081)) \\ &= 43.24 \end{aligned}$$

Total weighted parameter estimate = 43.25

For this parameter the EQ determined from Fig. 9 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.003 \\ \text{"With" EQ} &= 0.433 \end{aligned}$$

Therefore, the environmental impact on Sport Fisheries is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.433) - (14 \times 0.003) \\ &= (6.06) - (0.04) \\ &= +6.02 \end{aligned}$$

It seems strange, perhaps, that the total impact of the project on sport fisheries during the construction period cannot be less than zero using the Battelle EES. Actually, there certainly will be a negative impact on the small stream and pond fisheries of the reservoir basin. In the Battelle EES the environmental quality for this parameter is based on a modified estimate of water surface present expressed as a percentage of what will be there after the project is completed. We believe that the impact of construction on the parameter would be given a more realistic representation in the EES if it were computed solely on the basis of the water surface already present.

In this suggested modification of the Battelle system it would be necessary to determine a separate parameter estimate for the construction period and the use period for both the with and without project projections. It would then be necessary to first determine separately the construction period and use period environmental impacts, and second arrive at a single EI value by adding these two estimates after multiplication by a relative importance index. Thus, the total EI value would be made much more sensitive to the relative importance index selected for the construction and use periods, and it would then be possible to express negative impacts during the construction period.

As an example, if we calculate these values separately for the sport fish data we get the following:

Construction Period parameter estimates:

$$\begin{aligned}\text{Without project} &= ((0.10 \times 0.295) + (0.80 \times 70) + \\ &\quad (0.10 \times 0.081)) \\ &= 56.04\% \\ \text{EQ} &= 0.5604\end{aligned}$$

$$\begin{aligned}\text{With project} &= ((0.10 \times 0.205) + (0.80 \times 25) + \\ &\quad (0.10 \times 0.038)) \\ &= 20.0333\% \\ \text{EQ} &= 0.2003\end{aligned}$$

$$\begin{aligned}\text{With project Construction Period Impact EIU} &= ((14 \times 0.2003) - \\ &\quad (14 \times 0.5604)) \\ &= -5.0416\end{aligned}$$

Use period parameter estimates:

$$\begin{aligned}\text{Without project} &= 1.0 ((0.10 \times 0.343) + (0.80 \times 0.332) + \\ &\quad (0.10 \times 0.081)) \\ &= 0.308\% \\ \text{EQ} &= 0.0031\end{aligned}$$

$$\begin{aligned}\text{With project} &= ((0.10 \times 0.343) + (0.80 \times 60) + \\ &\quad (0.10 \times 0.081)) \\ &= 48.04\% \\ \text{EQ} &= 0.4804\end{aligned}$$

$$\begin{aligned}\text{Use Period EI} &= (14 \times 0.4804) - (14 \times 0.0031) \\ &= +6.7126\end{aligned}$$

If we now apply a 0.10 RI value to the construction period and a 0.90 RI value to the use period we obtain a total impact of:

$$\begin{aligned}\text{EIU} &= (0.10 \times -5.0416) + (0.90 \times 6.7126) \\ &= +5.5372\end{aligned}$$

or 0.4759 units less than the positive impact using the unmodified Battelle system.

This method of calculation allows for the possibility of negative impacts during construction whereas in the Battelle EES the construction period impact can only be expressed as a minimum EQ of zero.

Waterfowl

Waterfowl provide recreation in the form of hunting and, in many cases, a food source for man. As for upland game birds in a terrestrial ecosystem, waterfowl provide an estimate of productivity of an aquatic ecosystem. Waterfowl which have a potential to occur in sufficient numbers on the proposed site are gadwall, pintail, green-winged and blue-winged teals, American widgeon, and redhead duck.

A measure of waterfowl abundance may be made by assessing the quality and amount of wetland habitat in an area. The quality (K) of the wetland habitat is weighted on a 0 to 1 basis as shown in Table 5.

Table 5. Weighting scale used to establish quality (K) of wetlands.

| Description | Weight (K) |
|--|------------|
| High plant productivity, good water supply, year-round waterfowl usage, good waterfowl production, good hunting, good migrant bird usage | 1.0 |
| Moderate plant productivity, fluctuating water supply, some year-round waterfowl usage, limited waterfowl production, limited hunting, good migrant bird usage | 0.67 |
| Low plant productivity, intermittent water supply, limited waterfowl usage, no waterfowl production, poor hunting, limited migrant bird usage | 0.33 |

The parameter estimate for waterfowl is calculated by substituting wetland habitat area with and without the project. Currently, 464 acres of wetlands are found on the site in the form of small ponds. Inundation will result in a reservoir similar to Lake Dallas, just south of the Aubrey site. At Lake Dallas, about 0.33 of the reservoir is currently wetlands. This results in a projected wetlands area for the proposed Aubrey Reservoir of 11,683 acres (0.33 x 35050). The current wetland quality is poor with limited use by waterfowl and is rated 0.33 (Table 5). After inundation, the area should receive some waterfowl use, hunting should increase and a rating of 0.67 is projected. Utilizing the weighted values and current and projected wetlands, the Parameter Estimate is calculated as follows:

$$\text{Parameter Estimate} = \frac{\text{Wetland Habitat Area} \times K}{\text{Total Wetland Area}} \times 100$$

No impact on wetlands is foreseen above or below the site and these areas are given a spatial RI of 0. During construction, a RI of 0.10 is projected with a RI of 0.90 coming after inundation.

As calculated below, the EQ without the project is 0.33 and increases with the project to 0.63. This represents a

90% increase in the EQ for waterfowl for the proposed site. The reservoir should significantly add to current wetlands in north-central Texas. The importance of reservoirs as habitat for migratory game birds in Texas is evidenced by a westward shift in the Mississippi flyway to eastern and central Texas. Many species of waterfowl formerly using the Mississippi wetlands for migration have shifted to wetlands of the Texas and Oklahoma reservoirs. The Aubrey reservoir should enhance the chances for survival of these important wildlife in this area.

Weighted Parameter

$$\begin{aligned} \text{Estimate Without Project} &= 1.0 ((0 \times 0) + (1.0 \times \frac{464 \times 0.33}{464} \times 100) + \\ &\quad (0 \times 0)) \\ &= \frac{153}{464} \\ &= 33.0\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project-Construction} &= 0.10 ((0 \times 0) + (1.0 \times \frac{464 \times 0.33}{464} \times 100) + \\ &\quad (0 \times 0)) \\ &= 3.30\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project-Use} &= 0.90 ((0 \times 0) + (1.0 \times \frac{11683 \times 0.67}{11683} \times 100) \\ &\quad + (0 \times 0)) \\ &= 0.90 (\frac{7827.6}{11683}) \times 100 \\ &= 60.3\% \end{aligned}$$

Total weighted estimate with project = 63.3%

For this parameter the EQ determined from Fig. 10 is:

"Without" EQ = 0.33

"With" EQ = 0.63

Therefore, the environmental impact on Waterfowl is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.63) - (14 \times 0.33) \\ &= (8.82) - (4.62) \\ &= +4.2 \end{aligned}$$

Habitats and Communities

Habitats are physical environments in which particular sets of biota exist. The quality of a habitat influences the resident biotic composition. Therefore, it is important to ecological studies to have a "handle" on the quality of the habitat.

The set or collection of interacting populations of species within a given habitat is a biotic community. Biotic communities are extremely complex levels of ecological organization. They are ecological systems with three-dimensional physical or spatial structure; their components have horizontal and vertical dispersion patterns. Communities also have dynamic or functional structure, i.e., trophic or food web structure. This structure represents connectivities among individuals within the community along which energy flows in the form of organic compounds and inorganic nutrients cycle. The species and connectivities among them give rise to the properties which characterize a community.

The "health" of a community is difficult to assess. Essentially it represents how quickly a community can recover from a perturbation (i.e., its stability). This depends upon the sophistication and development of the cybernetics or feed-back regulatory mechanisms in the community.

Complete understanding of community dynamics, structure and control, and assessing the impact of perturbations require an extremely long, detailed and intensive study. Hence, it is important to choose several parameters which are easily measured and are good indicators of the "health" of biotic communities if the impacts of environmental projects on communities are to be assessed quickly. The following parameters used in this study were selected for the EES by Battelle-Columbus to reflect the structure and dynamics of communities.

Species Diversity and the Food Web Index appear to be adequate parameters to reflect the structure, stability and function of communities. However, these attributes of communities are quite difficult to determine and can only be approximated without detailed and lengthy study.

Terrestrial Habitats and Communities

Terrestrial Food Web Index

A community is composed of many species of organisms co-acting in a manner which connects each to all others. A basic interaction among organisms is energy flow. Energy in the form of organic nutrients flows among organisms belonging to different trophic (feeding) levels. These energy flow connectivities are collectively called a food web. Basic to any food web is the input of solar energy. Green plants (autotrophs) capture solar energy and convert it via photosynthesis to a form that can be utilized by non-photosynthetic organisms (heterotrophs). Plants are consumed by herbivores which are numerous in a community. In turn, herbivores are consumed by predators (carnivores) which are less numerous than the animals on which they feed. Certain animals eat both plants and animals and are considered omnivorous.

The complexity of interactions between herbivores, carnivores, and omnivores in a community provides an estimate of the complexity of a community. A valuable measure of community complexity and balance between trophic levels is a Food Web Index. Essentially, two important parameters of the organisms present in a community must be estimated: the number of kinds of organisms at a level and their density. Density determinations for all organisms requires an intensive and comprehensive community analysis which was precluded by the time limitations imposed by this study. Terrestrial organisms, are arranged in general trophic categories, and their density is weighted from 1 to 10 and ranked according to occurrence, where 0-3 = sparse, 3-7 = moderate, and 7-10 = abundant (Table 6). Because organisms in each trophic level conform in density to a pyramid with herbivores at the bottom and carnivores at the top, the logarithm of the density estimate for each group is used to reduce the large natural differences in trophic level size. Differences in weighting of importance (K) for herbivores, carnivores, and omnivores are also utilized and reflect differences in impact on the community (herbivores, $K=0.33$; carnivores, $K=0.67$; omnivores, $K=1.0$).

The Parameter Estimate (percent of maximum density) is calculated according to the following formula:

$$\text{Parameter Estimate} = \sum_{i=1}^N \frac{(\log_{10} \text{Trophic Category Group } i \text{ Density} \times K)}{(\log_{10} \text{Trophic Category Group } i \text{ Density})}$$

No impact on the terrestrial food web is predicted either upstream or downstream from the reservoir, and these areas are given a spatial RI value of 0. The site has a RI of 1.0. Construction will result in about a 10% reduction while inundation and use will cause a 90% reduction in the terrestrial food web, thereby giving 0-10 and 0.90 RI values for these, respectively.

The resulting environmental parameter measurement calculated below is 0.66 with PIU = 7.92 of a potential 12 units. (Fig. 11). During construction, it is expected that a 10% reduction in the food chain index will occur by disturbance. With inundation and destruction of the habitat, all organisms will be displaced reducing the index to 0. No effect is foreseen either upstream or downstream from the reservoir, as the carrying capacity and trophic diversity of these areas is already at its upper limits and should not increase.

$$\text{Parameter Estimate} = \frac{7.29}{11.12} = 0.66$$

$$\begin{aligned} \text{Weighted Parameter Estimate Without Project} &= 1.0 ((0 \times 0.66) + (1 \times 0.66) + (0 \times 0.66)) \\ &= 0.66 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter Estimate With Project-Construction} &= 0.10 ((0 \times 0.66) + (1 \times 0.66) + (0 \times 0.66)) \\ &= 0.07 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter Estimate With Project-Use} &= 0.90 ((0 \times 0.66) + (1 \times 0) + (0 \times 0.66)) \\ &= 0 \end{aligned}$$

$$\text{Total weighted estimate with project} = 0.07$$

For this parameter the EQ determined from Fig. 11 is:

"Without" EQ = 0.66

"With" EQ = 0.07

Therefore, the environmental impact on the Terrestrial Food Web Index is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (12 \times 0.07) - (12 \times 0.66) \\ &= (0.84) - (7.92) = -7.08 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"with" EQ} - \text{"without" EQ}}{\text{"without" EQ}} \times 100 \\ &= \frac{0.07 - 0.66}{0.66} \times 100 \\ &= - \frac{0.59}{0.66} \times 100 \\ &= -89\% \end{aligned}$$

which is a "Major Red Flag."

Table 6. Trophic organisms, trophic density, and trophic weight used in formulating the food web index for the proposed Aubrey Reservoir Site.

| Organisms | Density | Trophic Weight (K) |
|---------------------|---------|--------------------|
| <u>Herbivores</u> | | |
| Seed-eating Birds | 8 | 0.33 |
| Bobwhite | | |
| Morning Doves | | |
| Cardinals | | |
| Goldfinches | | |
| Hummingbirds | | |
| Rodents | 5 | 0.33 |
| Cotton rats | | |
| Rabbits | 8 | 0.33 |
| Insects | 10 | 0.33 |
| Grasshoppers | | |
| Crickets | | |
| True bugs | | |
| Cicadas | | |
| Aphids | | |
| Butterflies | | |
| Bees | | |
| Beetles | | |
| Other invertebrates | 8 | 0.33 |
| Millipedes | | |
| Earthworms | | |
| Roundworms | | |
| Pill bugs | | |
| <u>Carnivores</u> | | |
| Insectivorous Birds | 6 | 1.00 |
| Swallows | | |
| Flycatchers | | |
| Mockingbirds | | |
| Woodpeckers | | |
| Nighthawk | | |

Table 6 continued

| Organisms | Density | Trophic Weight (K) |
|---------------------|---------|--------------------|
| Raptorial Birds | 3 | 1.00 |
| Hawks | | |
| Owls | | |
| Vultures | | |
| Carnivorous Mammals | 2 | 1.00 |
| Coyotes | | |
| Spotted skunks | | |
| Snakes | 3 | 1.00 |
| Amphibians | 4 | 1.00 |
| Frogs | | |
| Toads | | |
| Salamanders | | |
| Insects | 5 | 1.00 |
| Beetles | | |
| Flies | | |
| Wasps | | |
| Other invertebrates | 5 | 1.00 |
| Spiders | | |
| Scorpions | | |
| Centipedes | | |
| <u>Omnivores</u> | | |
| Birds | 4 | 0.67 |
| Sparrows | | |
| Crows | | |
| Bluejays | | |
| Horned larks | | |
| Kingbirds | | |
| Meadowlark | | |
| Red-wing | | |
| Rodents | 2 | 0.67 |
| Deer mice | | |
| Harvest mice | | |

Table 6 continued

| Organisms | Density* | Trophic Weight (K) |
|---------------------|----------|--------------------|
| Other mammals | 4 | 0.67 |
| Skunks | | |
| Raccoons | | |
| Opposums | | |
| Insects | 5 | 0.67 |
| Other invertebrates | 3 | 0.67 |

*0-3 = sparse; 3-7 = moderate; 7-10 = abundant

Land Use

Land is divided on an areal basis in the EES into the following use categories: industrial, commercial, residential, agricultural, managed-forest and unmanaged or natural vegetation, that is, vegetation not controlled by man. We used the natural category for the edaphic climax forests in the site area even though they are disturbed by grazing and cutting.

Land is a valuable resource, but value depends to some extent upon the individual evaluating it. To some, operating at an inference level of understanding, it is mud that sticks to one's boots after a rain; to others, operating at a verbal level, it is real estate worth so much an acre; and to others, working at microscopic levels and who try to understand its physical and organic pedology, it is an unbelievably complex biophysical system beyond value, infinite in its variety and capacity to sustain autotrophic production.

Even so, land values may change at the verbal level of integration if a project causes a significant shift in the existing pattern of types. To assess such changes, the types were weighted according to the following EES classification:

| <u>Category</u> | <u>Weight</u> |
|-----------------|---------------|
| Industrial | 0 |
| Commercial | 0.2 |
| Residential | 0.4 |
| Agricultural | 0.6 |
| Managed Forest | 0.8 |
| Natural | 1.0 |

Note that the natural and industrial types are considered the most dissimilar and that the others are ranked in reference to these two extremes.

Extent of the types of land use was determined by grid intercepts from aerial photos of the project, field reconnaissance, and interviews with residents.

Parameter measure depended not only on extent but also on an importance weighting mentioned earlier. The raw and modified project site acres obtained were:

| <u>Land Use Type</u> | <u>Raw</u> | X | <u>Weight</u> | = | <u>Use Modified</u> |
|----------------------|--------------|---|---------------|---|---------------------|
| Industrial | 3 | | 0 | | 0 |
| Commercial | 441* | | 0.2 | | 88.2 |
| Residential | 250 | | 0.4 | | 100.0 |
| Agricultural | 30,496 | | 0.6 | | 18,297.0 |
| Managed forest | 0 | | 0.8 | | 0 |
| "Natural" | <u>4,554</u> | | <u>1.0</u> | | <u>4,554.0</u> |
| Totals | 35,744 | | | | 23,039 |

*Mostly the Jacobs Oil Field

All RI values and projected use-modified land use type changes were based on what has happened to Garza-Little Elm Reservoir since its construction over 15 years ago. The proposed Aubrey and Garza-Little Elm Reservoirs are about the same size and should be similar physically, as they are impoundments of the same stream and occur in the same geologic province.

The spatial RI values were estimated at 0.25 for the upstream area, 0.25 for the downstream area since the land use shifts did occur in these areas above and below. Time RI values are disproportionate also. A reservoir attracts commercial and residential changes in time so the short term or construction value was estimated at 0.4 and the long term operational value at 0.6.

Moreover, both "with" project acreage estimates included shoreline increases minus losses due to inundation, that is, residential acreage, for example, equals shoreline increase minus inundation loss times weight factor. Also, water-surface acreage was considered as recreational area belonging to the natural category; therefore, inundated acres are not lost but for the most part gain a higher weight (all except undated natural). The natural category acreage further reflects the 300 feet wide shoreline strip of vegetation that hopefully will result from the project.

Input of these data and considerations into the work-sheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir of +1.56 EIU on Land Use.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 (0.25 (23,039) + 0.50 (23,039) + \\ \text{Project} &\quad 0.25 (23,039) \\ &= 23,039 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.4 ((0.25 \times 22,780) + (0.5 \times 41,634) + \\ \text{Project-Construction} &\quad (0.25 \times 22,780) \\ &= 12,883 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.6 ((0.25 \times 19,940) + (0.5 \times 45,166) + \\ \text{Project-Use} &\quad (0.25 \times 19,940) \\ &= 19,532 \end{aligned}$$

Total weighted estimate = 32,415

To determine from Fig. 12, the weighted parameters were converted to percentages as follows:

$$\text{Parameter Estimate} = \frac{\sum^n (\text{Land Use Area} \times K)}{\text{Total Land Use}} \times 100,$$

where

N = Number of land uses

K = Weighted land use types

$$\begin{aligned} \text{"Without" PE} &= \frac{23,039}{69,800} \times 100 \\ &= 33\% \end{aligned}$$

$$\begin{aligned} \text{"With" PE} &= \frac{32,415}{69,800} \times 100 \\ &= 46\% \end{aligned}$$

For this parameter the EQ determined from Fig. 12 is:

"Without" EQ = 0.33

"With" EQ = 0.46.

Therefore, the environmental impact on Lane Use is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (12 \times 0.46) - (12 \times 0.33) \\ &= (5.52) - (3.96) \\ &= +1.56 \end{aligned}$$

RARE AND ENDANGERED TERRESTRIAL SPECIES

Plants or animals most sensitive to environmental change are usually those that are low in occurrence. Our general survey of plants and animals on the reservoir site was used to determine the existence of rare or endangered species. No rare or endangered animals were found, and only two plants can be considered to be rare or endangered. The plants are Uniola latifolia, broadleaf uniola, that is rare in Texas and Elymus canadensis, Canadian wild rye, considered endangered by the USDA, Soil Conservation Service, Temple, Texas, Feb. 1972.

To determine the value from Fig. 13 for Rare and Endangered Species, seven weighted categories are used as follows:

| <u>Category</u> | <u>Weight</u> |
|-----------------|---------------|
| Common | 10 |
| State Endemic | 9 |
| U.S. Endemic | 7 |
| State Rare | 5 |
| U.S. Rare | 3 |
| Endangered | 1 |
| Extinct | 0 |

The lowest category found on the project area is used to establish the parameter estimate, i.e., Parameter Estimate = Weight of the Least Common Species.

In this case, the least common species is Elymus canadensis, is endangered, and has a weight of 1.0. To use this value to establish a value function for endangered species, a consideration of construction and use periods is also

important. RI of 0.50 is assigned to both construction and use periods. A spatial RI of 1.0 was given to the site.

As calculated below and considering only the rare species, E. canadensis, the EQ for this parameter drops to 0 after inundation. This species will be reduced in Denton and Cooke Counties but not completely extincted from these areas.

Weighted Parameter

Estimate Without = $1.0 ((0 \times 0) + (1.0 \times 1) + (0 \times 0)) = 1.0$
Project

Weighted Parameter

Estimate With = $0.50 ((0 \times 0) + (1.0 \times 1) + (0 \times 0)) = 0.50$
Project-Construction

Weighted Parameter

Estimate With = $0.50 ((0 \times 0) + (1.0 \times 0) + (0 \times 0)) = 0$
Project-Use

Total weighted estimate with project = 0.50

For this parameter EQ determined from Fig. 13 is:

"Without" EQ = 1.00

"With" EQ = 0.50

Therefore, the environmental impact on Rare and Endangered Species is:

$$EIU = (PIU \times EQ_{with}) - (PIU \times EQ_{without})$$

$$= (12 \times 0.50) - (12 \times 1.0)$$

$$= -6.00$$

$$\% \text{ EQ change} = \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100$$

$$= - \frac{6.00}{1.20} \times 100$$

= -50% which is a "Major Red Flag."

Terrestrial Species Diversity

Species diversity is a measure of the biotic complexity of an ecological community. The biotic components of communities are individual organisms which belong to various species. There are two major components of species diversity: 1) varietal or richness, and 2) evenness. The former is a function of the number of different kinds of species whereas the latter is a function of the distribution of the individual organisms among the species. The maximum evenness for a given number of species, S , is when each is represented by the same absolute number, N , of individuals. In general, species diversity, both in richness and evenness is higher in mature or climax communities than in immature or seral communities. Therefore, species diversity represents a "handle" on the condition of a biotic community with respect to its maturity or age and degree of disturbance. Mature or climax communities are generally more stable, predictable and efficient in processing matter and energy (i.e., nutrient cycles and energy flow); they are closer to the steady state than less mature or preclimax communities. Ecologically, mature or climax communities are highly desirable; they strongly contribute to the overall "balance of nature."

There are numerous indices used to quantify species diversity. Some capture only the varietal components, whereas others consider the evenness component. The most desirable indices are those few which capture both components. However, a considerable amount of field work is required to obtain data necessary for these indices. Therefore, simpler ones are often used when time is limiting. The diversity index suggested by Battelle- Columbus (1) for their EES is:

$$S/1000N$$

where, S = number of species and N = number of individuals. This index captures the varietal or richness component. Discussion of its limitations is beyond the scope of this report.

Battelle-Columbus suggests that the dominant terrestrial plant species be used as indicators of overall terrestrial diversity. This undoubtedly is based on the assumption that dominant plants exert a controlling influence on animal species diversity as well as on subdominant plant species diversity. Although this concept is simple and useful, and probably valid, there is some evidence that plant species diversity per se does not have as much influence on animal species diversity as plant structural diversity does (20).

Species diversity is used in the EES to reflect the degree of disturbance and stability of biotic communities with and without a resource project. Therefore, it can be used to assess the impact of a resource project on the biotic stability of the environment.

Data on species and their densities were collected during the vegetational survey of the three major "natural" communities in the proposed Aubrey Reservoir site (Old Field, Upland Post Oak and Streamside Forests) by using the "expanding quadrat method." Quadrats were set out from points which were placed in each community type as to avoid ecotone effects. Quadrats were systematically enlarged from each point until 1000 individuals were counted; and the number of species per 1000 N was determined. Table 7 shows the results of the sampling.

Prior to 1835 practically all of the 35,050 acres of the reservoir site (at the upper guide contour) were in Upland Post Oak (28,700 acres) and Streamside (6,350 acres) Forests. Only a small portion was in midgrass prairie. Presently, approximately 13% of the area is covered by forests, most of which are severely disturbed by cutting and grazing. Reasonable approximations of S/1000 N in "virgin" Streamside and Upland Post Oak Forests, based on "best" available extant stands in the North Texas area are 13 S/1000 N and 15 S/1000 N respectively (Roach, unpublished). Since the highest EQ (=1.0) for species diversity obtains when there are approximately 15 S/1000 N, the value function graph (Fig. 14) should be modified from 0 - 10 to 0 - 15 S/1000 N for this study. Based on the assumption that 15 S/1000 N has an EQ = 1.0, the present site EQ can be determined as follows:

The approximate area presently covered by forests is 4554 acres. Streamside and Upland Post Oak Forests represent approximately 25 and 75% of this area respectively. Therefore, to use the formula for the parameter estimate given

by Battelle-Columbus:

$$\text{Parameter Estimate} = \frac{\text{Mean Number of Species in All Communities}}{1000 \text{ Individuals}}$$

a "weighted" mean based on the relative areal extent of each community must be calculated. Since $\bar{X} S/1000 N$ is 11.38 and 6.33 for Streamside and Upland Post Oak Forests respectively (Table 7), the "weighted" mean is calculated as $((4 \times 6.33) + (1 \times 11.83)) / 5 = 7.43S/1000N$.

An index of 7.43S/1000N gives an EQ of just over 0.5 from a modified value function graph (Fig. 14) in which 15 S/1000N = EQ of 1.0. However, since only approximately 13% of the area covered with forests in 1835 is presently covered, the EQ = 0.5 applies to only 13% of the site area. The remainder (87%) is abandoned old field and cultivated. Since the species diversity of the old field is as high as the "virgin" forests, consideration of old field species diversity with Fig. 14 would produce an unrealistically high EQ. The high varietal component of species diversity in old fields does not reflect their stability or desirability. Because of this, only the forests and the areal approximations above were considered in this parameter.

A "weighted" EQ for the entire site area based on 7.43S/1000 N of the forests (EQ = 0.5), their present areal extent compared to that prior to 1835, and an arbitrarily assigned EQ = 0 for old fields and cultivated areas, is $((0.13 \times 0.5) + (0.87 \times 0))/1.0 = 0.065$. This EQ captures the present EQ of the proposed Aubrey Reservoir site in terms of how close the entire 35,050-acre site is to the desirable edaphic climax condition of the last century. Using an EQ = 0.065, the S/1000 N "adjusted" or extrapolated to the entire site area is approximately 1.3. Cutting prior to inundation of the site will virtually destroy the forests, thereby reducing the on-site EQ to zero.

The spatial frames upstream, site and downstream were given RI's of 0.1, 0.8, and 0.1 respectively. The temporal frames with the project, construction and use period were given RI's of 0.25 and 0.75 respectively because of the relative amount of time each period will affect terrestrial species diversity.

The upstream and downstream "weighted" species diversity parameter estimate also is considered to be 7.43 S/1000 N.

The reservoir is expected to have negligible effect on species diversity in these areas.

Input of these data into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir project of -0.91 EIU on Terrestrial Species Diversity.

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Measurement Without} &= 1.0 ((0.1 \times 1.3) + (0.8 \times 1.3) + \\ \text{Project} &\quad (0.1 \times 1.3)) \\ &= 1.30 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.25 ((0.1 \times 0) + (0.8 \times 0) + \\ \text{Project-Construction} &\quad (0.1 \times 0)) \\ &= 0 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.75 ((0.1 \times 0) + (0.8 \times 0) + \\ \text{Project-Use} &\quad (0.1 \times 0)) \\ &= 0 \end{aligned}$$

Total parameter estimate with project = 0.

For this parameter the EQ determined from Fig. 14 would be:

$$\begin{aligned} \text{"Without" EQ} &= 0.065 \\ \text{"With" EQ} &= 0 \end{aligned}$$

Therefore, the environmental impact on Terrestrial Species Diversity is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0) - (14 \times 0.065) \\ &= (0) - (0.91) \\ &= -0.91 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0 - 0.065}{0.065} \times 100 \\ &= -100\% \quad \text{which is a "Major Red Flag."} \end{aligned}$$

Table 7. Species diversity of dominant terrestrial plants in three major "natural" communities in the proposed Aubrey Reservoir site.

| Community (area in acres) | | S/1000 N |
|--------------------------------|------------------------------|-------------------|
| Number of samples | Location of sample | |
| | | |
| Old Field (26,635) | | |
| 1 | <u>Ambrosia</u> dominated on | 20 |
| 2 | silty soil | 24 |
| 3 | | 15 |
| 4 | <u>Aristida</u> dominated on | 11 |
| 5 | sandy soil | 25 |
| 6 | | 13 |
| 7 | Bermuda - sprigged | 13 |
| 8 | | 11 |
| 9 | | 7 |
| | | $\bar{X} = 15.4$ |
| Upland Post Oak Forest (3,438) | | |
| 1 | Eastern arm of | 4 |
| 2 | reservoir site | 5 |
| 3 | | 7 |
| 4 | Western arm | 8 |
| 5 | | 5 |
| 6 | | 6 |
| 7 | Central section | 7 |
| 8 | | 10 |
| 9 | | 5 |
| | | $\bar{X} = 6.33$ |
| Streamside Forest (1,116) | | |
| 1 | Along Elm Fork | 8 |
| 2 | | 15 |
| 3 | | 13 |
| 4 | Along Isle du Bois | 11 |
| 5 | | 10 |
| 6 | | 14 |
| | | $\bar{X} = 11.83$ |

Although the EQ change is -100%, a "Major Red Flag" exaggerates the impact because the "without" EQ is quite low for Terrestrial Species Diversity.

We recommend that as much area as possible around the reservoir be "encouraged" to return to or remain in forest. This will partially offset the "Major Red Flag."

Aquatic Habitats and Communities

Aquatic Food Web Index

The Food Web Index is a measure of the balance between the trophic levels and food web through which organic food (energy) flows, and inorganic nutrients cycle.

The density of organisms is the magnitude measured in the EES system. The use of absolute densities for all organisms requires a comprehensive community analysis, beyond the time available for this study. A suitable alternative is to use natural trophic subcategory groupings under each of the three major levels (herbivores, omnivores, carnivores) then assign them a relative abundance magnitude based upon available data and professional judgment of the evaluator. Relative abundance magnitude is given on a scale of 1 - 10, where 0 - 3 = Sparse, 3 - 7 = Moderate and 7 - 10 = Abundant. Approximate changes predicted for the reservoir site are given in Table 8, and are given a spatial RI of 0.7. In some of the categories given in Table 8 (e.g., insect grazers), densities during the construction (RI = 0.2) and use (RI = 0.8) phases will also include a complete change in species composition, from lotic to lentic species. Specific organisms given are examples, and are not intended to represent a complete listing.

Using Table 8 and the formula:

$$\text{Parameter Estimate} = \frac{\sum_{i=1}^n (\log_{10} \text{Trophic Subcategory Group}_i \text{ Density} \times K)}{\sum_{i=1}^n (\log_{10} \text{Trophic Subcategory Group}_i \text{ Density})}$$

where,

K = Feeding habit modifier (increasing weight from 0.33 for herbivores, 0.67 for omnivores, and 1.0 for carnivores reflects the respective regulatory roles of these levels)

the percent of maximum density now is 58. Similar treatment of predicted changes during construction and use periods yielded 52 and 47%, respectively, on the site area. Downstream changes, given a lesser RI of 0.3 were estimated. An initial decrease in downstream density would result primarily from siltation from construction in the ca. first 2 miles; thereafter, a significant increase in overall downstream density would result (see element report on Aquatic and Terrestrial Invertebrates). Reduction in on site Percent Maximum Density would primarily be due to a gradual shift to more omnivores.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -0.24 EIU on the Aquatic Food Web Index.

Weighted Parameter

$$\begin{aligned}\text{Estimate Without} &= 1.0 ((0 \times 58) + (0.7 \times 58) + (0.3 \times 58)) \\ \text{Project} &= 58\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.2 ((0 \times 58) + (0.7 \times 52) + (0.3 \times 50)) \\ \text{Project-Construction} &= 10.3\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.8 ((0 \times 58) + (0.7 \times 47) + (0.3 \times 80)) \\ \text{Project-Use} &= 45.5\end{aligned}$$

Total weighted estimate with project = 55.8

For this parameter, the EQ determined from Fig. 15 is:

$$\begin{aligned}\text{"Without" EQ} &= 0.58 \\ \text{"With" EQ} &= 0.56\end{aligned}$$

Therefore, the environmental impact on Aquatic Food Web Index is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (12 \times 0.56) - (12 \times 0.58) \\
 &= (6.72) - (6.96) \\
 &= -0.24
 \end{aligned}$$

Table 8. Trophic organisms, density, and feeding habit modifiers for the Aubrey Reservoir site.

| Organisms | Density* with Project | | | Feeding Habit Modifier |
|---|--------------------------|------|------|---------------------------|
| | Now | 5 | 15 | |
| <u>Herbivores</u> | | | | |
| Insect Grazers (Mayflies, riffle beetle larvae, <u>Simulium</u>) | 8* | 6*** | 6*** | 0.33 |
| Fishes (<u>Dorosoma</u>) | 1 | 5 | 5 | 0.33 |
| Crustacea (<u>Palaemonetes</u>) | 2 | 2 | 2 | 0.33 |
| Mollusca (<u>Viviparus</u>) | 1 | 3 | 3 | 0.33 |
| Amphibia larvae | 0.5 | 0.5 | 0.5 | 0.33 |
| <u>Omnivores</u> | | | | |
| Insects (Cheumatopsyche, Chironomidae) | 5** | 6*** | 6*** | 0.67 |
| Fishes (<u>Cyprinus</u> , <u>Ictalurus</u> , <u>Notropis</u>) | 2 | 4 | 4 | 0.67 |
| Oligochaete worms (<u>Branchiura</u>) | 1 | 4 | 6 | 0.67 |
| Mollusca (<u>Sphaerium</u>) | 1 | 2 | 2 | 0.67 |
| <u>Carnivores</u> | | | | |
| Insects (<u>Erpetogomphus</u> , <u>Ophiogomphus</u> , <u>Hetaerina</u> , <u>Argia</u> , <u>Corydalus</u> , <u>Perlesta</u>) | 2** | 1*** | 1*** | 1.00 |
| Fishes (<u>Lepisosteus</u> , <u>Noturus</u> , <u>Pylodictus</u> , <u>Pomoxis</u> , <u>Lepomis</u> , <u>Microp-</u> <u>terus</u> , <u>Morone</u> , <u>Etheostoma</u>) | 2 | 3 | 2 | 1.00 |
| Reptiles (<u>Agkistrodon</u> , <u>Natrix</u> , <u>Trionyx</u>) | 0.5 | 0.1 | 0.1 | 1.00 |

* 0-3 = sparse; 3-7 = moderate; 7-10 = abundant

** Lotic Species

*** Lentic Species

Rare and Endangered Aquatic Species

Rare and endangered species include those that are uncommon or rare and those which because of a restricted distribution or other circumstances are in danger of extinction.

The parameter estimate (EQ) is determined from the weight of the lowest (least common) species (Fig. 16). Since all aquatic plant and animal species at the proposed site are common, the value of 10 is used in interpreting the present EQ of 1.0. Therefore, since inundation will not have an effect on this parameter, the impact index of the Aubrey Reservoir Project on Rare and Endangered Aquatic Species would be 0 EIU.

River Characteristics

The proposed Aubrey Reservoir will change the flowing water habitat in the area extensively. Some areas will be inundated and lost. The upstream lotic environment will be altered by the close proximity of a large reservoir. For example, some of the upper reaches of Elm Fork and Isle du Bois Creek may be utilized as spawning sites by white bass and crappies migrating from the new reservoir. The characteristics of Elm Fork below the dam will change considerably when flows are stabilized and the water quality changes.

In applying the Battelle EES the parameter magnitude is percent of total surface area of streams in the area modified by a quality modifier which varies from 0 to 1 according to the following scale:

| <u>Category</u> | <u>Weight</u> |
|-----------------|---------------|
| No flow, dry | 0 |
| Hot spring | 0.25 |
| Fluctuating | 0.50 |
| Warm | 0.75 |
| Cold | 1.00 |

Because many of the small streams in the upstream area are intermittent in flow during the summer months we assigned them a quality modifier of 0.50. In the reservoir site 28 acres of stream were judged to be intermittent and were given a quality modifier of 0.50; while the remaining 42.8 acres of stream (primarily Elm Fork) usually flow all year and so were given a modifier of 0.75. The entire 25.4 acres of Elm Fork in the downstream area was given a modifier of 0.75.

During construction of the reservoir no change in quality modifier is anticipated for the upstream area. At the reservoir site it is expected that construction activities will alter flows and increase summer temperatures and turbidities. Therefore, the construction period modifiers were reduced from 0.75 to 0.50 at the reservoir site and from 0.75 to 0.60 in the downstream area. During the use period the quality modifier upstream is unchanged; at the reservoir site it is 0; and downstream it is increased to 0.80 to reflect an expected stabilization of flow and lowering of summer water temperatures as a result of the operation of the dam.

River characteristics are given 12 PIU's in the Battelle EES. Input of these data into a worksheet-matrix and calculations below yielded an impact index of -1.44 EIU on River Characteristics.

Weighted Parameter

$$\begin{aligned} \text{Estimate Without} &= 1.0 ((0.20 \times 50) + (0.50 \times 65.11) + \\ \text{Project} &\quad (0.30 \times 75)) \\ &= 65.06\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.10 ((0.20 \times 50) + (0.50 \times 50) + \\ \text{Project-Construction} &\quad (0.30 \times 60)) \\ &= 5.3\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.90 ((0.20 \times 50) + (0.50 \times 50) + \\ \text{Project-Use} &\quad (0.30 \times 60)) \\ &= 47.7\% \end{aligned}$$

Total weighted estimate = 53.0%

For this parameter the EQ determined from Fig. 17 is:

"Without" EQ = 0.65

"With" EQ = 0.53

Therefore, the environmental impact on River Characteristics is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (12 \times 0.53) - (12 \times 0.65) \\ &= (6.36) - (7.8) \\ &= -1.44 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.53 - 0.65}{0.65} \times 100 \\ &= -18.5\% \quad \text{which is a "Major Red Flag."} \end{aligned}$$

Aquatic Species Diversity

Species diversity is a parameter that reflects to some extent successional maturity and community stability. Diversity indices may be used to compare maturity and stability of communities from different habitats or geographical areas.

Benthic invertebrates are used in the Battelle-Columbus EES as indicators of overall aquatic diversity. The index used is Number Species per 1000 Individuals (S/1000N). This was calculated in conformance with the EES by plotting the log of the number of individuals (y-axis) against the number of species (x-axis), accumulated from stations I - V (see elements reports on Aquatic and Terrestrial Invertebrates). This produced a value of 19S/1000N.

Since the value function graph (Fig. 18) developed by Battelle-Columbus (1) allows only 10S/1000N to produce an EQ of 1.0, an arbitrary new scale of 0-30S/1000N was used here, based on the judgment and experience of the evaluator that similar sampling in an optimum local stream would produce a maximum value of ca. 30S/1000N. Similar treatment of data from the nearby Brazos River yielded a value of 23S/1000N (Stewart, unpublished). On the above basis, the present EQ in the reservoir site was approximated at 0.63 from the value function graph (Fig. 18).

In calculations that follow, spatial RI's are given as 0.0 upstream, 0.5 on site and 0.5 downstream. These are based on predictions that there will be no upstream effect with the project, and that recreational and esthetic consid-

erations would lend equal weight to the reservoir created and the modified stream below.

Construction RI's are set at 0.2, since the macrobenthos are vagile and capable of quick recovery from construction. The more important Use RI is given a weight of 0.8.

Species diversity of macrobenthos on site will decrease to an estimated 10S/1000N during construction, then to ca. 9S/1000N during the use period. This will almost be offset by an overall increase downstream (although there will be a decrease for the ca. first 2 miles downstream and overall during the construction phase) during the Use period to ca. 25S/1000N.

Input of these values and estimates into the worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -1.26 EIU on Aquatic Species Diversity.

Weighted Parameter

$$\begin{aligned}\text{Estimate Without} &= 1.0 ((0 \times 19) + (0.5 \times 19) + (0.5 \times 19)) \\ \text{Project} &= 19\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.2 ((0 \times 19) + (0.5 \times 10) + (0.5 \times 17)) \\ \text{Project-Construction} &= 2.7\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.8 ((0 \times 19) + (0.5 \times 9) + (0.5 \times 25)) \\ \text{Project-Use} &= 13.6\end{aligned}$$

Total weighted parameter estimate = 16.3

For this parameter the EQ determined from Fig. 18 is:

$$\begin{aligned}\text{"Without" EQ} &= 0.63 \\ \text{"With" EQ} &= 0.54\end{aligned}$$

Therefore, the environmental impact on Aquatic Species Diversity is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (14 \times 0.54) - (14 \times 0.63) \\
 &= (7.56) - (8.82) \\
 &= -1.26
 \end{aligned}$$

$$\begin{aligned}
 \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\
 &= \frac{0.54 - 0.63}{0.63} \times 100 \\
 &= -14.28 \quad \text{which is a "Major Red Flag."}
 \end{aligned}$$

Ecosystems

Ecosystems are levels of biological organization which include the biotic community and its abiotic environment. Although ecosystems are currently being intensively studied by community and systems ecologists, few comprehensive data are available for the complex attributes (e.g., nutrient budgets, biogeochemical cycles, decomposition and transformation, energy flow, productivity, hydrological budgets) of more than a few ecosystems. Consequently, Battelle-Columbus includes Ecosystems as only a descriptive component in their EES.

Since detailed descriptions of major components of the ecosystems in the proposed Aubrey Reservoir site appear in the Botanical and Zoological Elements of the Environmental Elements section, and in reports on numerous EES parameters, only a brief account of these ecosystems is given here.

Natural ecosystems in the proposed Aubrey Reservoir site have been extensively modified by grazing of cattle, agricultural practices and cutting trees for fuel and construction since the mid-19th century. Presently the 35,050 acres (area at upper guide contour) in the proposed site are divided among the following terrestrial ecosystems: Post Oak Forest (3,438), Streamside Forest (1,116), abandoned Old Field (26,635) and Cultivated (3,861 acres). Prior to 1835, the two "natural" ecosystems, Streamside and Post Oak Forests covered approximately 6,300 and 28,700 acres respectively. Although the "climatic climax" for this area is midgrass prairie, with little bluestem being dominant, edaphic factors (mainly sandy soil derived from Woodbine sandstone) enable Post Oak Forest ecosystems to prevail on the uplands above the flood plains of

Isle du Bois and Elm Fork where as a result of stream deposits and abundant Streamside Forests occur.

Man's impact on these two "natural" ecosystems in the proposed site has been extensive. Even the remaining forests are heavily grazed, reducing their esthetic and heuristic values, as well as their contribution to the stability of the watershed and biosphere. All the terrestrial ecosystems in the site area are disturbed. The construction of the Aubrey Reservoir will result in the replacement of several disturbed ecosystems by one of a different type. The impact of the Aubrey Reservoir Project on the natural terrestrial ecosystems can be considered a result of a "trade off." That is, instead of the area being used for production of cattle and crops, it will be used to supply water to metropolitan areas, for flood control and for recreation. Since the extant "natural" ecosystems are of low quality (EQ), the total impact of this "trade off" probably will be positive, that is, the change from the present terrestrial disclimaxes to an aquatic disclimax should have a greater significance to people living outside the area, than they presently derive from importing crops, meat and dairy products produced in the site area. If as in several of the Human Interest Parameters, external significance is weighted higher than internal significance, then the reservoir with its benefits for hundreds of thousands of people outside the site area represents a more favorable disclimax than those extant in the site.

However, from the ecological point of view which considers natural ecosystems, their relationship to their watersheds, the biosphere, and the "balance of nature" in general, the edaphic climax Post Oak and Streamside Forests are preferred to either disclimax.

"Natural" aquatic ecosystems in the proposed site are streams and small tributaries. The two principal ones are Isle du Bois and Elm Fork. Most of their tributaries are intermittent in the site area. Approximately 70.8 acres of the site are covered by streams with Elm Fork and Isle du Bois accounting for 33.3 and 20.4 acres respectively. These streams have moderately high secondary production and fairly complex food webs. The major energy input to the streams is from allocthonous materials; primary production is fairly low.

Environmental Pollution

This category contains four components and 24 parameters. These were selected by Battelle-Columbus for the EES because they are easily measured and have been used frequently in the past to determine the quality (degree of pollution) of the environment, and are likely to be affected by water resource projects.

The quality of the environment is steadily declining because of man's activities. These activities generally result in changes in quality, quantity, and distribution of physical, chemical and biological elements of the environment. Therefore, by carefully measuring selected physical, chemical and biological parameters, the impact of water resource projects can be assessed.

The major environmental components which are likely to be affected by water resource projects are: water, air, land, and noise pollution.

Water Pollution

The nature of water resource projects makes this a very important component of the EES. It is designed to evaluate changes in water quality, quantity and distribution associated with the project.

Basin Hydrologic Loss

Basin hydrologic loss is expressed as a ratio between losses of water from a basin due to man-made developments and losses due to natural annual discharges. Man-made losses include those losses that result from evaporation of water from a reservoir. Natural loss is that amount of water lost at the mouth of a river or creek due to discharge.

The total amount of water consumption is considered in this study. Water consumption, resulting from the combined actions of evaporation, evapotranspiration, and seepage, is found to be twice the average annual consumption attributable

to evaporation alone. Therefore, total consumption is considered in deriving the EQ for Basin Hydrological Loss.

The data used to establish the EQ was obtained from the United States Geological Survey, USGS Water Supply Paper, No. 1984. Data on Garza-Little Elm for the years 1928-1966 are:

| | |
|---------------------|-------------------|
| Net Inflow = | 4,181,400 acre Ft |
| Rainfall in Pools = | 356,800 acre Ft |
| Pool Consumption = | 967,800 acre Ft |
| Net Depletion = | 611,000 acre Ft |
| Outflow = | 3,571,600 acre Ft |

$$\frac{\text{Man-made losses}}{\text{Natural losses}} = \frac{611,000 \text{ acre feet (net depletion)}}{4,181,400 \text{ acre feet (net inflow)}}$$

An EQ = 0.98 is established from the value function graph in Fig. 19 for Basin Hydrologic Loss for the present period.

Initially, following construction of the project, a 10% loss of yield has been calculated for this area of the Trinity River, according to the USGS report. This depletion has been included into the formula to predict the EQ with the project. Hence, the EQ for the construction period is derived as:

$$\frac{611,000 \text{ acre feet} \times 0.10 + 611,000 \text{ acre feet}}{4,181,000 \text{ acre feet}} =$$

$$\frac{611,000 \text{ acre feet} + 61,000 \text{ acre feet}}{4,181,000 \text{ acre feet}} = 16.1\%$$

Reading from the value function graph, an EQ = 0.96 is predicted for the construction period. The loss of yield, according to the USGS, will decrease to 1% or less at some time within 30 years after the project is constructed. Therefore, the value function would return to normal, and the impact of the Aubrey Reservoir Project on Basin Hydrologic Loss in EIU = 0.

Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) is defined as an estimate of the quantity of oxygen required by an ecosystem to biologically oxidize the organic contents in an aquatic environment. Therefore, a test for BOD provides a means for measuring the organic pollution load of an aquatic system. The BOD data reported in this EES study represents those obtained from 5 day BOD tests as well as those extrapolated from TOC (total organic carbon) analyses. Both the TOC and the BOD tests reflect the organic carbon load of a given aquatic ecosystem.

A Beckman Model 915 Total Organic Carbon Analyzer was used to determine the amount of TOC present in the samples. The principle of the TOC analyzer method is that all inorganic carbon in the sample is converted to CO_2 which is measured by non-dispersive infrared analysis. The difference between this total carbon value and a value obtained for total inorganic carbon from the same sample represents the organic carbon content of the sample. A stoichiometric relationship exists between the amount of CO_2 formed from combustion and the amount of O_2 utilized. Each milligram of organic carbon oxidized requires 2.7 mg of oxygen. This relationship was used in calculating a theoretical oxygen demand (BOD estimate).

The organic carbon range for the four stations in this study was 6-26 mg/l, and the weighted average for all samples was 12 mg/l. The lowest concentration was determined at the Elm Fork station, some 6 miles downstream from the entrance of a wastewater effluent. The highest concentrations were detected immediately below the sewage effluent outfall, which averaged 26 mg/l.

The 26 mg/l measurement, according to Fig. 20 is given an $\text{EQ} = 0.5$. This is based on the curve given for swift streams.

Upstream is given an $\text{RI} = 0.20$ because the prediction is that the BOD concentrations of the influents will remain quite constant for some time. The site is assigned an $\text{RI} = 0.60$ as the BOD was observed to decrease in samples from this area, hence, this area is most influential in BOD reduction. The downstream should reflect a BOD similar to that of the site.

The construction of the Aubrey Reservoir should improve the BOD parameter initially at the site because of the dilution factor as well as the scheduled improvement of the Gainesville wastewater plant. However, during the use period, organic and inorganic matter will become soluble in the water of the reservoir resulting in an increase in the BOD to a predicted level of 12 mg/l.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project of +7.5 EIU.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0.2 \times 30) + (0.6 \times 6) + \\ \text{Project} &\quad (0.2 \times 6)) = 10.8 \text{ mg/l BOD} \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.25((0.2 \times 30) + (0.6 \times 6) + \\ \text{Construction Period} &\quad (0.2 \times 6)) = 2.7 \text{ mg/l BOD} \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.75((0.2 \times 30) + (0.6 \times 12) + \\ \text{Use Period} &\quad (0.2 \times 8)) = 11.1 \text{ mg/l BOD} \end{aligned}$$

Total weighted estimate with project = 13.75 mg/l BOD.

For this parameter the EQ determined from Fig. 20 is:

"Without" EQ = 0.5

"With" EQ = 0.8

Therefore, the environmental impact on Biochemical Oxygen Demand is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (25 \times 0.8) - (25 \times 0.5) \\ &= (20) - (12.5) \\ &= +7.5 \end{aligned}$$

Dissolved Oxygen

Dissolved oxygen (DO) is that amount of oxygen which is found in solution in water. The amount of DO found in water is influenced by such factors as turbulence, temperature, and biological activity. The influence of oxygen tension on aquatic communities has been well documented, particularly in pollution studies.

DO measurements of the various water sources for the proposed reservoir were made with the Winkler method (21). Samples were fixed in the field and titrated in the laboratory. The samples were collected from the following locations: 1) the intersection of I-35 and Elm Fork, 2) at Elm Fork immediately below the confluence with the city of Gainesville's treated waste discharge, 3) the intersection of Elm Fork and State Highway 455, and 4) Isle du Bois Creek at State Highway 455.

Although a definite depression of oxygen saturation was noted at the station immediately below the Gainesville effluent, subsequent reaeration was evidenced by near-saturation values obtained further downstream. DO concentrations for all stations were found to average about 7.5 mg/l (90-100% saturation) at ambient temperatures. Based on this figure, an EQ = 0.95 may be assigned from the value function graph (Fig. 21) for the present condition. No significant variation from the present condition is expected for the near future without the reservoir project.

It is expected that with construction and initial impoundment a significant decline in DO may occur. This will result principally from inundation and subsequent decomposition of vegetation. During early impoundment this may result in a decline of DO to approximately 60-80% saturation at the surface of the reservoir and 0-20% near the bottom. The extreme values near the bottom would be a result of such factors as decomposing rooted vegetation, absence of light for photosynthetic oxygenation and remoteness from surface aeration. A volume-weighted DO concentration decline would most likely be of the order of 2.0 mg/l for the initial year of inundation. This estimate is based on IES (Institute for Environmental Studies, NTSU) data obtained for initial inun-

dation for Toledo Bend Reservoir. Averaged for the projected 5-year construction period, this would result in an annual DO departure from normal of 0.4 mg/l. From this value an EQ = 0.90 may be derived from Fig. 21.

Following inundation and initial oxygen tension stabilization, it is predicted that an on-site negative departure of 0.5 mg/l DO from the 7.5 mg/l value assigned tributary waters may be expected on an annual basis for the reservoir. This prediction is based upon an annual volume-weighted DO average estimate and IES data for several local reservoirs. This estimate considers temporary large departures from normal accompanying thermal stratification and hypolimnetic stagnation during summer months.

A similar departure from normal stream DO values of -0.5 mg/l is predicted for the immediate downstream area during and following construction of the reservoir. This prediction is based on the reported results of numerous investigations of the effects of impoundments on downstream water quality (Symons et al., 22). Observations by IES of conditions immediately downstream from local reservoirs indicate that reaeration of hypolimnetic discharges is usually accomplished within relatively short distances (usually less than 0.5 mile).

Input of these data into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -1.55 EIU on Dissolved Oxygen.

Weighted Parameter

Measurement Without Project = $1.0((0.20 \times 7.5) + (0.60 \times 7.5) + (0.20 \times 7.5)) = 7.5 \text{ mg/l DO}$

Weighted Parameter

Estimate With Project = $0.25((0.20 \times 7.5) + (0.60 \times 7.1) + (0.20 \times 7.1)) = 1.795 \text{ mg/l DO}$

Weighted Parameter

Estimate With Project = $0.75((0.20 \times 7.5) + (0.60 \times 7.1) + (0.20 \times 7.1)) = 5.385 \text{ mg/l DO}$

Total weighted parameter estimate with the project = 7.18 mg/l DO.

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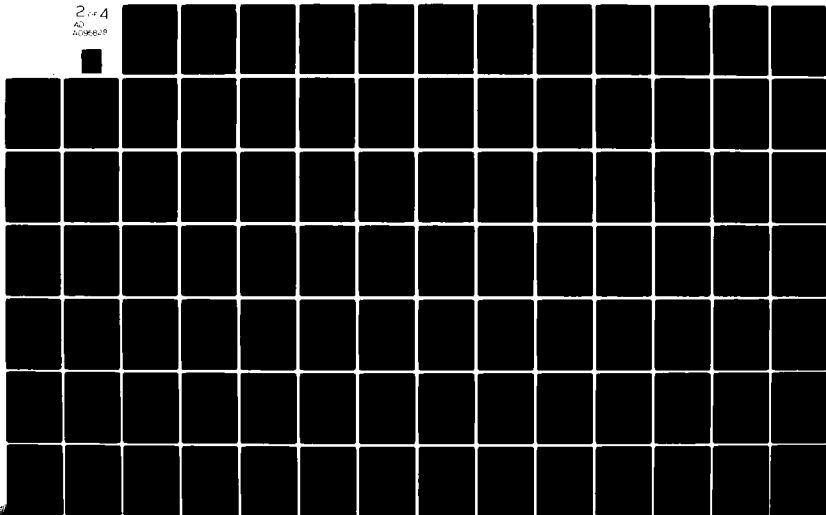
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A SYSTEMS EVALUATION OF THE ENVIRONMENTAL IMPACT OF THE AUBREY --ETC(U)
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For this parameter the EQ determined from Fig. 21 is:

"Without" EQ = 0.95

"With" EQ = 0.90

The environmental impact on Dissolved Oxygen is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (31 \times 0.90) - (3. \times 0.95) \\ &= (27.90) - (29.45) \\ &= -1.55 \end{aligned}$$

Fecal Coliforms

Fecal coliforms are Gram-negative, aerobic or facultative anaerobic, non-sporulating, rod-shaped bacteria which have the capacity to ferment lactose with the production of gas at 45 C. These organisms are the most widely used bacteriological indicator system to demonstrate the presence of fecal matter from warm-blooded animals. They are indicative of the degree of contamination contributed by fecal wastes. The sanitary significance of this group of bacteria is well authenticated (23). Hence, this test is the basis for existing standards used to determine the bacteriological quality of water supplies.

The fecal coliform densities were calculated from Most Probable Number (MPN) tables (21). An arithmetical mean of 3.0×10^3 fecal coliforms per 100 ml was derived by using the average fecal coliform load that would be contributed by each station. Based on this weighted parameter measurement, an EQ = 0.5 is derived from Figure 22.

The Aubrey Reservoir site is located in a geographical area which is primarily used for farming and ranching. Consequently, it is rather sparsely populated at the present time. However, the population of this area should show a substantial increase in the next 20 years as a result of the construction of the new regional airport. This area would be considered an ideal place to live and commute to the metropolitan region. So, in essence, the population of the locale will increase regardless of whether or not the reservoir is built. There will be an increase in the number of homes, and waste disposal

will most probably be via septic tanks and primarily treated sewage. However, these factors will most likely be negated because the city of Gainesville plans to improve its wastewater treatment facility through federal government funding. Also, the Environmental Protection Agency will place more stringent restrictions on the installation of septic tanks in the future.

Presently, deterioration of the bacteriological quality of the creeks of the watershed is almost inevitable. However, the construction of the new reservoir will cause an initial decrease in the fecal coliform density by dilution, probably to the 10^2 fecal coliforms per 100 ml level. During the use period, the fecal coliform density is predicted to increase to 10^3 fecal coliforms per 100 ml. This will result if inadequately treated sewage and septic tank seepage gains access to the reservoir.

Since the present fecal coliform density was determined to be at the 10^3 level the EQ is 0.5 (Fig. 22). Also, if the density decreases to 10^2 levels during the construction period and increases to 10^3 concentrations during the use period, the EQ still equals 0.5. Therefore, the environmental impact of the Aubrey Reservoir Project on the Fecal Coliform parameter is EIU = 0.

Total Inorganic Carbon

Total inorganic carbon (TIC) of an aquatic system is the sum of carbon existing as carbon dioxide, bicarbonate, and carbonate. Inorganic carbon is a major carbon source for photosynthetic organisms and, thus, is necessary for the maintenance of the aquatic food web. Although inorganic carbon is usually present in sufficient quantities to support algal growth, there is growing evidence that, in some instances of low concentrations (particularly in soft waters), it may be a significant algal growth limiting factor.

Inorganic carbon was measured with a Beckman Model 915 Carbon Analyzer. Analyses of samples indicated an average of 54 mg/l TIC. This concentration represents an EQ = 1.0 as shown in Fig. 23. TIC concentrations of this level probably will not cause excessive primary productivity, nor, be limiting to algal growth. A change in magnitude to 70 mg/l would have to occur before the EQ would decrease. An EQ = 1.0 is expected with the project. This is supported by research data obtained

from IES studies on other area reservoirs which show the average TIC concentrations of 20-25mg/l. Subsequently, no demonstrable stress would be placed on this parameter during construction period of the reservoir.

Calculations using estimated inorganic carbon concentrations yielded concentrations of 62.8 mg/l TIC. This level estimate was derived by estimating that the TIC at the upstream area would not change. The concentration at the site was estimated to initially decrease to 40 mg/l during the construction period, but increase to 80 mg/l during the use period. The spatial frames were given the following RI assignments: upstream = 0.20, the site = 0.60, and the downstream area = 0.20.

The weighted parameter estimate for the construction period would be 11.2 mg/l TIC and the use period would be 51.6 mg/l TIC by using the above predicted estimates. Thus, the TIC concentration with the project would be 62.8 mg/l. Fig. 23 shows that a TIC concentration of 62.8 mg/l has an EQ = 1.0 because the EQ does not change until TIC concentration reaches 70 mg/l.

Therefore, the Aubrey Reservoir Project is predicted to have an impact of 0 EIU on the TIC.

Total Inorganic Nitrogen

Nitrogen is a micronutrient essential to all living organisms and plays a fundamental part in governing community structure and function within the aquatic ecosystem. Inorganic nitrogen is often a growth determining factor in the aquatic environment. Ammonia, nitrite, and nitrate are all possible nitrogen sources for most green plants. Thus, considering the influence of nitrogen on water quality, it is appropriate to consider the TIN content of the water. This is the total of ammonia, nitrite and nitrate-nitrogen.

To determine TIN concentrations for this study, ammonia and nitrite-nitrogen were measured by the methods of Truesdale (24), and nitrate nitrogen determined by the modified brucine technique (21). These values were summed to estimate TIN.

The EQ of a water supply is given a value of 1.0, if the TIN concentration reaches a level of no more than 1 mg/l (Fig. 24). The lower limit of the range is 0.3 mg/l. Below this concentration nitrogen is often considered limiting in the aquatic environment. Concentrations above 1 mg/l TIN often stimulate nuisance algal and macrophyte conditions.

TIN samples taken in this study had concentrations ranging from 0.3 to 2.7 mg/l. The sample influenced by a waste effluent (Elm Fork immediately below Gainesville) contained the highest amount of TIN, the majority of which was ammonia. However, biological oxidation was evident as samples taken downstream showed a reduction in the ammonia content from 86 to 25% of the TIN. A proportional increase in nitrates was observed in the downstream samples. The mean TIN concentration for all sampling stations was 2.5 mg/l. Although an inordinant influence was exerted on this mean by samples taken immediately below the release of a sewage effluent, it was considered a good estimate of TIN for the basin system at upstream, on-site, and downstream locations. Employing the value function graph (Fig. 24) and the mean TIN value an EQ = 0.85 was assigned the upstream, site, and downstream locales. This value is not expected to significantly change during the construction period either. Therefore, an EQ = 0.85 is assigned this period.

Based on IES observations from other local reservoirs, it is expected that impoundment for Aubrey Reservoir will result in a reduction in the TIN levels at the on-site and downstream locales. This would be mainly attributable to dilution effects and biological precipitation. IES data for several local reservoirs show a pronounced seasonal fluctuation in TIN concentrations with the greatest values occurring in the late winter and smallest in late summer. Based on these data an average TIN of 0.5 mg/l is estimated for the use period of the proposed reservoir and downstream waters. This value is assigned an EQ = 1.0 from the value function graph (Fig. 24).

On an areal basis, the upstream, site, and downstream locations have been assigned RI's of 0.20, 0.60, and 0.20 respectively. On a temporal basis the construction and use periods of the reservoir have been assigned RI's of 0.25 and 0.75 respectively.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project of +4.25 EIU on TIN.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0.20 \times 2.7) + (0.60 \times 2.7) + \\ \text{Project} &\quad (0.20 \times 2.7)) \\ &= 2.7 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.25 ((0.20 \times 2.7) + (0.60 \times 0.5) + \\ \text{Project-Construction} &\quad (0.2 \times 0.5)) \\ &= 0.235 \text{ mg/l TIN} \end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.75 ((0.20 \times 2.7) + (0.60 \times 0.5) + \\ \text{Project-Use} &\quad (0.2 \times 0.5) \\ &= 0.71 \text{ mg/l TIN}\end{aligned}$$

Total weighted parameter estimate with project = 0.94 mg/l TIN.

For this parameter estimate the EQ determined from Fig. 24 is:

$$\begin{aligned}\text{"Without" EQ} &= 0.80 \\ \text{"With" EQ} &= 0.97.\end{aligned}$$

Therefore, the environmental impact on TIN is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (25 \times 0.97) - (25 \times 0.80) \\ &= (24.25) - (20) \\ &= +4.25\end{aligned}$$

Inorganic Phosphate

Phosphorus is one of the three elements most essential for sustaining life. It occurs in various forms in water, and may be found in both soluble and particulate phases. Phosphorus is often the growth determining nutrient which accelerates the rate of eutrophication.

Inorganic phosphate analyses were performed by the ascorbate method (21). The critical range for phosphates in water is apparently from 0.005 to 0.02 mg/l, the lower end of which is a nutrient deficient region and the upper level is the concentration at which algal blooms can be initiated.

An EQ = 0 is given the Inorganic Phosphate parameter for the upstream area without the project because analyses showed that the inorganic phosphate level averaged 0.5mg/l. This concentration is five times greater than the value assigned an EQ of 0 in Fig. 25. Values in excess of 2.0 mg/l were common in samples taken from the Elm Fork immediately below the Gainesville treated sewage influent.

Phosphate averages at the site and further downstream were about 0.27 mg/l. Consequently these areas are also assigned an EQ of 0.

Dilution and physical and biological precipitations should cause a net decrease in the inorganic phosphate content of the water when the reservoir is constructed. IES data for Garza-Little Elm Reservoir indicate a rapid loss of phosphate entering the reservoir from a tributary carrying the effluent of Denton's sewage treatment plant. Based on this and phosphate concentration data for other local reservoirs it is predicted that during the use period of the reservoir, on-site and downstream phosphate concentrations will probably not exceed 0.06 mg/l and will probably average about 0.03 mg/l. However, according to Fig. 25, an EQ of 0.0 must be assigned to the use period for both the on-site and downstream areas.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of 0 EIU on Inorganic Phosphate.

Weighted Parameter

$$\begin{aligned}\text{Measurement Without} &= 1.0 ((0.20 \times 0.5) + (0.60 \times 0.27) + \\ \text{Project} &\quad (0.20 \times 0.27)) \\ &= 0.32 \text{ mg/l}\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.25 ((0.20 \times 0.5) + (0.60 \times 0.06) + \\ \text{Project-Construction} &\quad (0.20 \times 0.06)) \\ &= 0.04 \text{ mg/l}\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.75 ((0.20 \times 0.5) + (0.60 \times 0.03) + \\ \text{Project-Use Period} &\quad (0.20 \times 0.03)) \\ &= 0.12 \text{ mg/l}\end{aligned}$$

Total weighted estimate with project = 0.16 mg/l Total Inorganic Phosphate.

For this parameter the EQ determined by Fig. 25 is:

$$\text{"Without" EQ} = 0.0$$

$$\text{"With" EQ} = 0.0$$

Therefore, the environmental impact on Inorganic Phosphates is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (28 \times 0) - (28 \times 0) \\ &= 0\end{aligned}$$

Pesticides

Pesticides represent a broad category of chemical compounds including insecticides, herbicides, and algicides. These compounds are used to control animal and plant pests. The biological effects vary greatly among compounds and biological species. The literature is replete with data concerning the effects and dosages of the various pesticides. Dogs, mice, rats, fish, and humans have been studied in these investigations. Valuable information has been obtained, and bases have been established for sub-toxic, toxic, and LD₅₀ levels for pesticides.

Present methods employed in the detection and quantitation of pesticides in the environment are rather limited in scope and accuracy. Hence, their value is questionable. During this EES study, actual testing for pesticides was not performed because of time limitations. The value function was established by extrapolating published data that had been obtained from samples downstream.

The Texas Water Development Board reported results of test analyses that their research group determined on samples taken at a station approximately 35 miles south of Dallas, Texas during 1969 (Report #120, September, 1970). Concentrations at this station were considered to reflect the amounts of various pesticides that were present farther back upstream. We are of the opinion that concentrations would be higher here because of runoff and dumping that could have occurred in both the metropolitan and farming areas below the Aubrey Reservoir site.

A total of seven pesticides were detected and quantitated in $\mu\text{g}/\text{l}$ quantities at Rosser, Texas by the Texas Water Development Board team. These data were converted to mg/l concentrations and compared to the recommended maximum permissible limits for drinking water standards that have been developed by the FWPCA. All detected pesticides were well below the permissible limits for drinking water, therefore, each pesticide singly can be given an EQ = 1.0. However, when more than one pesticide is detected and quantitated in water, it must be integrated into a broader formula in order

to derive the overall environmental quality value. Using the following formulation:

$$EQ = \left(\sum_{i=1}^n EQ_i / n \right) \times \left(0.9^n \right),$$

where

EQ = overall environmental quality re: pesticides
 EQ_i = environmental quality for pesticide i obtained from Fig. 26
 n = number of pesticides

An EQ = 0.4782969 (0.5) is calculated for the present condition without the reservoir.

The following pesticides were detected at a station at Rosser, Texas during the 1968 water year: DDD, DDE, DDT, dieldrin, lindane, 2,4-D, and 2,4,5-T. The concentration of each pesticide was converted to mg/l quantities and compared to the recommended permissible limits in drinking water. The weighted mean for 2,4,5-T was 0.0001 mg/l, and the average value for dieldrin was 0.0001 mg/l. These two pesticides were found in the largest quantities. These concentrations are well below the maximum permissible levels, but since most of these compounds accumulate in the environment, these levels have probably increased to date. So, the data from this study were extrapolated to the Aubrey Reservoir study because there are no test results for this particular part of the water basin.

Pesticides undoubtedly will gain access to the reservoir by means of the influent streams. Although the reservoir will not cause an increased use of pesticides, it will act as a "sink" accumulating pesticides and increasing their entrance into the local aquatic food web. Therefore, the accumulation of pesticides should be a primary consideration with the reservoir. Hence, it is assumed that the concentrations of pesticides as a whole will continue to increase in the aquatic environment until tolerance and use recommendations are made more stringent by the federal and state governments.

Assuming that the pesticide concentrations will continue to accumulate to a concentration level of a ratio that is equivalent to 0.6, then according to Fig. 26, an EQ = 0.4 is

predicted for the construction and use periods with the project.

The spatial RI evaluation is as follows: upstream is given an RI = 0.45 because of the contribution due to input by runoff and much of this area is agricultural and supports ranching activities: the site is also given an RI = 0.45 because of accumulative and concentration effects: and the downstream is given a value of 0.10 because a substantial amount of pesticides will be removed through precipitation in the reservoir, thus, this region of the proposed project area should have a lower level of pesticides than either the upstream or site areas.

The construction and use periods are each given an RI = 0.50 because pesticides will continue to accumulate during both periods, provided that restraint is not applied in the use of those compounds included in the category of pesticides.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project of -1.6 EIU on Pesticides.

Weighted Parameter

Measurement Without Project = $1.0((0.45 \times 0.5) + (0.45 \times 0.5) + (0.10 \times 0.5)) = 0.5 \text{ conc. ratio}$

Weighted Parameter

Estimate With Project Construction Period = $0.5((0.45 \times 0.6) + (0.45 \times 0.6) + (0.10 \times 0.6)) = 0.3 \text{ conc. ratio}$

Weighted Parameter

Estimate With Project Use Period = $0.5((0.45 \times 0.6) + (0.45 \times 0.6) + (0.10 \times 0.6)) = 0.3 \text{ conc. ratio}$

Total weighted estimate with project = 0.6 concentration ratio.

For this parameter the EQ determined from Fig. 26 is:

"Without" EQ = 0.5

"With" EQ = 0.4

Therefore, the environmental impact on Pesticides is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (16 \times 0.4) - (16 \times 0.5) \\ &= (6.4) - (8.0) \\ &= -1.6 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.4 - 0.5}{0.5} \times 100 \end{aligned}$$

= -20% which is a "Minor Red Flag."

Hydrogen-Ion Concentration (pH)

The hydrogen ion concentration (pH) is defined as the negative log of the molar concentration of hydrogen ions present in an aqueous solution. A pH of 7.0 indicates neutrality with increasing values (to 14) indicating a basic condition, and lower values (to 0) representing acidic conditions. Values for most natural waters vary between 6.5 and 8.5.

Samples were brought into the laboratory and pH measurements were made with a Beckman Expandomatic SS-2 pH meter. The average pH was 7.9, which is characteristic for water in this area. The value function graph (Fig. 27), shows two values that can be used in the assignment of an EQ for pH. ORSANCO uses pH 7.0 as natural, whereas NSF uses 7.3 as natural. However, a deviation from these pH standards might not necessarily be a departure from the natural pH of a particular aquatic system. Thus, the best measurement of the impact of pH on environmental quality is its effects on the aquatic biota.

The EQ value for pH 7.9, as given in Fig. 27, is 0.90 and 0.85 respectively based on the ORSANCO and NSF values (1). It is expected that there will be some diurnal and vertical departures from normal within the reservoir. However, no substantial change is predicted to occur in the pH because of the construction and use of the Aubrey Reservoir. Thus, an EQ = 1.0 is assigned for these periods.

The RI spatial value assignment is interpreted to be distributed as 0.20, 0.60, and 0.20 between the upstream, site, and downstream frames respectively. The temporal importance absolute value is distributed between the construction and use periods as 0.25 and 0.75 respectively.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of 0 EIU on Hydrogen Ion Concentration (pH).

Weighted Parameter

$$\begin{aligned} \text{Measurement Without Project} &= 1.0((0.20 \times 7.9) + (0.60 \times 7.9) + \\ &\quad (0.20 \times 7.9)) = 7.90 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project Construction Period} &= 0.25((0.20 \times 7.9) + (0.60 \times 7.9) + \\ &\quad (0.20 \times 7.9)) = 1.98 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project Use Period} &= 0.75((0.20 \times 7.9) + (0.60 \times 7.9) + \\ &\quad (0.20 \times 7.9)) = 5.92 \end{aligned}$$

Total weighted estimate with project = 7.91.

For this parameter the EQ determined from Fig. 27 is:

$$\text{"Without" EQ} = 0.90$$

$$\text{"With" EQ} = 0.90$$

Therefore, the environmental impact on Hydrogen Ion Concentration is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (18 \times 0.9) - (18 \times 0.9) \\ &= (16.20) - (16.20) \\ &= 0 \end{aligned}$$

Stream Flow Variation

Stream flow variation is expressed as the ratio between the maximum and minimum flow changes that occur in a stream with relation to time. This parameter is very important ecologically because environments can be drastically altered if the magnitude and frequency of these variations occur rapidly and for prolonged periods of time.

The value function for stream flow is derived by the integration of parameter measurements into four function graphs as shown in Figures 28, 29, 30 and 31. All data used in establishing the weighted parameter measurement were obtained from the Corps of Engineers. The following formula is used to generate an overall EQ score for the stream flow variation parameter:

$$EQ = \sum_{i=1}^n f_i$$

where n = number of curves needed to account for total range of variation.

Three value function graphs (Figs. 28, 29 and 30) were used to satisfy the total range of flow variation and these included the following maximum/minimum flow ratios: 2:1, 2:1 - 10:1, and 10:1 - 50:1. It was calculated that in 97% of the time, the flow ratio was 2:1, with the change occurring in 24 hr, or longer, 2% of the time the ratio was 2:1 - 10:1 (change occurring in 24 hr), and 1% of the time the ratio was 10:1 - 50:1, occurring in a 24 hr period. Using the value function graph in Fig. 28, an EQ = 1.0 is given this flow (2:1) period. Fig. 29 gives an EQ = 0.7 for the 2:1 - 10:1 range, and Fig. 30 assigns an EQ = 0.6 for the stream flow ratio range of 10:1 - 50:1.

The overall EQ was derived as follows:

$$\begin{aligned} EQ &= ((0.97 \times 1.0) + (0.02 \times 0.7) + (0.01 \times 0.6)) \\ &= (0.97 + 0.014 + 0.006) \\ &= 0.99 \end{aligned}$$

Hence, an EQ = 1.0 is given the Stream Flow Variation parameter, presently, and although some modification in the flow rate may occur during the construction and use periods, no significant change in the characteristic flow pattern is predicted. So, an EQ = 1.0 is given these two periods. Therefore, the Aubrey Reservoir Project should not have an impact on the Stream Flow Variation parameter. Hence, the impact EIU = 0.

Temperature

The temperature or thermal content of an aquatic system is perhaps the most important factor in delineating the ecology of that system. The content of dissolved gases such as oxygen and carbon dioxide is regulated by temperature dependent solubilities. Temperature exerts significant influence on chemical equilibria in natural waters (25), and, of course, dictates the solution rates for various minerals.

The unique physical properties of water are to a large degree regulated by temperature. This relationship is one of the most important factors in maintaining the fitness of water as an environment (26). Hutchinson (27) considers the thermal properties of lakes a good basis for a lake classification scheme.

The influence of temperature in regulating growth, life cycles, and distribution of organisms is well known. The influence of temperature on metabolism in the aquatic environment relates to food consumption and food supply. Welch (28) states, "In warmer waters, aquatic organisms have a greater daily food requirement; conversely, they have a smaller daily requirement in cold waters. Expressed otherwise, the same standing crop of food will support more animals in the colder regions than in the warmer ones."

The natural surface temperatures of lakes and streams are generally governed by the amount of solar radiation that they receive. Thus, within a given geographic region one would not expect wide deviations in surface water temperatures. Regarding this study the only deviation from natural temperatures is predicted to occur with construction of the reservoir, and this deviation is expected to be significant only in the summer months. During periods of intense surface heating and low wind-induced circulation (June-September) at least temporary periods of thermal stratification may occur. During such periods a difference of 5-10 C between surface and bottom may be expected. This phenomenon would be manifest in tailwaters which might be 5-10 C colder than surface waters of the reservoir and its tributaries.

Based on our measurements and comparison with IES data from other area streams and reservoirs an EQ = 1.0 is assigned to the temperature parameter considering no reservoir construction. With construction of the reservoir, however, it is predicted that an average annual deviation from normal temperatures of approximately 3 C may be expected in the downstream area. Based on this figure an EQ = 0.7 can be assigned from the value function graph (Fig. 32) for the downstream area following construction and during the use period of the reservoir. It is further expected that during the summer season a large deep pool of water will exist within the reservoir which will be (5-10 C) cooler than surface waters. A volume-weighted temperature average might, at this time, indicate a negative departure from normal surface water temperatures. On an annual basis this deviation might be expected to average about 3 C. Premised on this expectation an EQ = 0.7 may be assigned the on-site area for the periods following construction of the reservoir. No departure from normal temperatures is expected during construction until closure of the dam for either downstream or on-site locations.

Input of these data in a worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of -1.4.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0.20 \times 0) + (0.60 \times 0) + \\ \text{Project} &\quad (0.20 \times 0)) = 0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.25((0.20 \times 0) + (0.60 \times 0) + \\ \text{Construction Period} &\quad (0.20 \times 0)) = 0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.75((0.20 \times 0) + (0.60 \times 3) + \\ \text{Use Period} &\quad (0.20 \times 3)) = 1.8 \end{aligned}$$

The total weighted estimate with the project is 1.8 EIU.

For this parameter the EQ determined from Fig. 32 is:

"Without" EQ = 1.0

"With" EQ = 0.95

Therefore, the environmental impact on Temperature is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (28 \times 0.95) - (28 \times 1) \\ &= (26.6) - (28.0) \\ &= -1.4 \end{aligned}$$

Total Dissolved Solids

Total dissolved solids (TDS) is a measure of all soluble materials dispersed in solution in a water supply. The concentration of these substances plays a vital role in the biological activity in water and, thus, are important to the overall quality of water. High concentrations of dissolved substances may be hazardous to irrigation because an imbalance in the equilibrium of certain of these materials could have adverse effects on either the irrigation pipes or crops.

TDS were determined by evaporation of sample volumes in tared crucibles at 103-105 C until a constant weight was obtained (usually 48 hr). TDS were estimated from conductivity data using the relationship:

$$\text{TDS} = A \times \text{Specific Conductance} \quad (29)$$

The coefficient, A, usually lies between 0.55 and 0.75, and for this study was estimated to be 0.6. Specific conductance was determined with a YSI Conductivity Meter according to Standard Methods (21). Suspended solids were measured by subtracting the dissolved solids from the total solids.

The EQ for TDS is based on specific conductivity data derived from samples. An EQ = 1.0 in given waters containing less than 750 mg/l TDS and specific conductances be -0-1000 electrical conductance (EC) units. The present parameter estimate is based on the average of the sample which contained the highest amount of total solids and the highest specific conductivity. No appreciable change is predicted in the future without the reservoir.

Impoundment should cause a characteristic decline in the amount of TDS. Evaporation may manifest itself occasionally in increased TDS concentrations, however, any change is predicted to lie within the acceptable quality range. Therefore, an EQ = 0.9 is predicted for both the "with" and "without" project periods.

The spatial RI is divided between the upstream (0.75) and the site (0.25). The upstream water supply will contribute the greater quantity of total dissolved solids into the

reservoir. Present data support this statement. A wide spectrum of substances will be taken into solution as the streams, with their run-off, enter the reservoir. The site is given some consideration because, following inundation, all types of organic materials will be dissolved in the water.

Temporal RI values are 0.60 for the construction period and 0.4 for the use period. The greatest impact on TDS should be a slight increase when the project is initiated. In time, however, this should be modified as equilibrium will be regained.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project of EIU = 0 on Total Dissolved Solids.

Weighted Parameter
Measurement Without Project = $1.0((0.75 \times 870) + (0.25 \times 688)) = 825 \text{ mg/l}$

Weighted Parameter
Estimate With Project = $0.6((0.75 \times 870) + (0.25 \times 688)) = 495 \text{ mg/l}$
Construction Period

Weighted Parameter
Estimate With Project = $0.4((0.75 \times 870) + (0.25 \times 688)) = 330 \text{ mg/l}$
Use Period

Total weighted estimate with project = 825 mg/l TDS.

For this parameter the EQ determined from Fig. 33 is:

"Without" EQ = 0.95

"With" EQ = 0.95

Therefore, the environmental impact on Total Dissolved Solids is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (25 \times 0.95) - (25 \times 0.95) \\ &= (23.75) - (23.75) \\ &= 0 \end{aligned}$$

Toxic Substances (Except Pesticides)

Toxic compounds are those substances in water that cause harm or death to the organisms in the aquatic ecosystem by altering some metabolic activity. Examples of toxic substances that may gain access to and be detected in water are the heavy metals (mercury, lead, cadmium, zinc, copper, chromium), gasoline and other petroleum products, phenolic compounds, ABS, LAS, PCB, hydrocarbons, and industrial and domestic wastes.

The effects of toxic substances in water range from odor production or organoleptic properties to toxicity and death of the affected organism. Adequate toxicological data specific for many of these compounds is insufficient. However, sensitive analytical equipment and technology have been developed so that the detection and quantitation of many of these compounds is quite accurate. Therefore, it has been possible to recommend maximal permissible concentrations for many of these toxic compounds in surface water.

Concrete pertinent data concerning toxic compounds were, for the most part, unavailable for this area of the Trinity River Basin although research on such compounds is gaining increased attention from both state and federal agencies. The only actual parameter measurement that was established during the current EES study was through personal communications with Dr. Tom Gray. One of the heavy metals, arsenic, has been detected in bottom sediments from Garza-Little Elm Reservoir in concentrations of one part per 10,000. Therefore, the assumption is made that this chemical, as well as others, possibly exist in waters and sediments of upstream areas.

Since the value function graph (Fig. 34) is developed on a detectable-non-detectable basis, an $EQ = 0$ is given the parameter Toxic Substances.

The problem with toxic substances is predicted to be compounded in the future because of the continued use of certain defoliants, such as those containing arsenic, in some regions of the watershed. Therefore, an $EQ = 0$ is assigned to the construction and use periods.

The Aubrey Reservoir will have no impact on the Toxic Substances parameter, therefore, the $EIU = 0$.

Turbidity

Turbidity is any suspended matter in water, such as clay, silt, finely divided organic or inorganic matter, plankton, and any other microscopic organisms which impede the transmittance of light. This aggregation of particles either scatter or absorb the light. Turbidity, therefore, is an indicator of the amount of suspended matter, or solids, in water.

Turbidity is considered an important parameter in an EES study because it reduces the environmental quality of water. Excess turbidity may cause a decrease in primary production which is essential for the secondary production of fish food organisms. It can alter physiological functions of aquatic organisms, and it can also result in undesirable temperature increases.

Turbidity measurements were made in this study using a Jackson Turbidimeter. These data, as well as other data from area reservoirs and creeks were compared in order to establish a weighted measure for this parameter. The range for turbidity was 50-500 Jackson Turbidity Units (JTU) for the analysed samples. The highest turbidities were recorded following rain periods with subsequent runoff and increased flow rates in the streams. The overall turbidity average was 210 JTU while the average turbidity, without considering the rain periods, was 115 JTU. The latter mean was used in the evaluation and as the weighted measurement without the project because, in our opinion, this average is a more representative value as more of the days per year in this region are without rain. The weighted parameter measurement at and below the confluence of Isle du Bois Creek and Elm Fork was 85 JTU.

Taking the higher upstream mean, which was 115 JTU turbidity, and charting this value on the value function graph in Fig. 35, an $EQ = 0.1$ is given the turbidity parameter for the without project period. The spatial RI value is considered to be equally assigned to the upstream and site areas. A value of 0.45 RI is given for these areas, and the downstream is considered and assigned an $RI = 0.10$.

The upstream tributaries will bring silt into the reservoir basin, especially during the rainy season, thus, being a causative factor in increased turbidity. However, sedimentation will occur in the reservoir and will offset a majority of the deterioration to the turbidity EQ. The downstream region should improve some as a result of the project, hence, an RI = 0.10 is given here.

During the construction period turbidity in the reservoir should increase rather substantially because of the physical characteristics of the terrain in the basin and adjacent parts of the watershed. The turbidity is projected to reach a level of 200-300 JTU. According to the value function graph in Fig. 35, an EQ = 0 is assessed this JTU estimate. During the use period, the turbidity is expected to decline, mainly as a result of sedimentation. It is assumed that the turbidity will decrease at least to the JTU level that is observed in the influents at the present time. This being the case, an EQ = 0.15 can be assigned to the use period from the value function graph in Fig. 35.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +1.0 EIU on Turbidity.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0.45 \times 120) + (0.45 \times 115) + \\ \text{Project} &\quad (0.10 \times 85)) = 114.2 \text{ JTU} \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.2((0.45 \times 120) + (0.45 \times 250) + \\ \text{Construction Period} &\quad (0.10 \times 250)) = 38.30 \text{ JTU} \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.8((0.45 \times 120) + (0.45 \times 60) + \\ \text{Use Period} &\quad (0.10 \times 65)) = 70.0 \text{ JTU} \end{aligned}$$

Total weighted estimate with project = 108.3 JTU.

For this parameter the EQ determined from Fig. 35 is:

"Without" EQ = 0.10

"With" EQ = 0.15

Therefore, the environmental impact on Turbidity is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (20 \times 0.15) - (20 \times 0.10) \\ &= (3.0) - (2.0) \\ &= +1.0 \end{aligned}$$

Air Pollution

Water resource projects can indirectly result in air pollution in numerous ways. Several of these are: 1) increased automobile traffic in the area; 2) motor boats; and 3) housing, business and industry developments near the lake.

Data used in this section were obtained from Dr. W. G. Johanson, Southwestern Medical School, Dallas, Texas.

Carbon Monoxide

Carbon monoxide (CO) is an odorless, colorless, and tasteless gas emanated from automobile exhausts. The major concern with carbon monoxide is the fact that this gas is capable of chemically uniting with hemoglobin in the red blood cells of humans and other vertebrate animals. The rate of this chemical formation is a function of the concentration of CO in the blood.

The data used to determine the environmental quality of the CO parameter were from the Dallas-Ft. Worth metropolitan area. So, essentially, a higher concentration of the gas is probably being used in the derivation of the value than actually exists in this particular region at the present time.

Carbon monoxide data from the Dallas area for the summer of 1971 showed that the maximum 1 hr level was 16.6 mg/M³. In order to evaluate this concentration from the value function graph pertaining to CO in Fig. 36, it was necessary to convert the measurement to milligrams per liter (ppm). Dividing 16.6 mg/M³ by 1000 yields a concentration of 0.20 mg/l CO. Fig. 36 shows that the most critical range for CO in drastically affecting the EQ is 20-30 mg/l. An EQ = 1.0 is given for the CO parameter without the project in accordance with the value function graph.

The construction and use of the project is not predicted to cause CO concentrations to reach levels which will cause a reduction in the EQ for the parameter. Such a prediction is made for several reasons. In the first place, the concentrations in the metropolitan areas is substantially higher than in areas in which there is less urbanization. Also

to support this statement, Region 8 (including Dallas, Ft. Worth, and Denton) is placed in Category III with respect to carbon monoxide concentrations in the air. Categorically speaking, III is the best of the three classifications. Secondly, it could be argued that this area is more of a rural than urban area, and carbon dioxide levels are much lower in the rural areas. Lastly, the Aubrey will probably be included to the flight patterns of landings and takeoffs of planes entering and leaving Dallas-Ft. Worth via the new regional airport. Such extreme stress factors, adding to carbon monoxide, have been considered in the data used for Dallas. Therefore, sufficiently more air pollution will be a little consequence in the area.

The construction of the reservoir, and its use, is predicted to not have any adverse effect on the environmental quality with respect to CO. Therefore, the impact of the Aubrey Reservoir Project on this CO is EIU = 0.

Hydrocarbons

Hydrocarbons are those pollutants that result mainly from incomplete oxidation of petroleum products and are emitted from automobile exhausts. These compounds serve as precursors for oxidation reactions which result in smog formation.

The only data that could be obtained for this study showed that, by comparison, hydrocarbon pollutants in three air pollution study regions in Texas were approximately 1.5 times greater in concentrations detected as were the concentrations reported for the nitrogen oxides. It was only by this comparison that a measurement could be derived.

Since this value was a very small concentration, the value function graph in Fig. 37 assigns an EQ = 1.0 to this parameter without the project. The concentration of hydrocarbons has to reach a level of 0.05 ppm before a depression is noted in the EQ value on the function graph.

The Aubrey Reservoir Project is predicted to not have an adverse effect on the hydrocarbon parameter because the present levels of these noxious compounds is very low and even with increased activities in the area the accumulation of these compounds is not expected to reach levels that will cause a deterioration in the environmental quality. Therefore, the impact of the Aubrey Reservoir Project on the Hydrocarbon parameter is EIU = 0.

Nitrogen Oxides

Oxides of nitrogen participate in photochemical reactions which ultimately lead to smog formation. Nitric oxide results from the combustion engines in automobiles and the exhausts of power plants. Nitric oxide is oxidized to nitrogen dioxide (NO_2) which is involved with other air pollutant constituents in smog production.

The nitrogen oxides parameter was not actually measured in this EES study. The parameter measurement was obtained from investigations made in the Dallas-Ft. Worth, Wichita Falls, and in the Tyler areas. The estimated annual arithmetical mean for the Dallas area for nitrogen oxides was 126 micrograms per cubic meter (mcg/M^3) for the year 1971. In Wichita Falls, the arithmetical mean for the same year was established to be 65 mcg/M^3 . Following consultation with experts in the field of air pollution, it was decided that a value between those given for Dallas and Wichita Falls would serve as a reasonable basis in order to derive a measurement for this parameter. Hence, a midpoint value of 95 mcg/M^3 was used to establish a measurement in order to develop a function from Fig. 38. If 95 $\mu\text{g}/\text{M}^3$ are converted to mg/l (ppm), one obtains 0.000095 mg/l , and this value can be used to determine the EQ for nitrogen oxides.

The value function graph (Fig. 38) shows that a concentration of this magnitude can be given an $\text{EQ} = 1.0$. The construction and use of the reservoir project is not predicted to have an adverse effect on the Nitrogen Oxides parameter. Although there will be more boating activity on and a noted increase of automobiles to the reservoir area, their additions of nitrogen oxides to the environment should be rather insignificant. This is based on low levels of nitrogen oxides near U.S. Highway I-35 which is quite heavily traveled at the present time. Therefore, the environmental impact of the Aubrey Reservoir Project on Nitrogen Oxides is $\text{EIU} = 0$.

Particulate Matter

Particulate matter is the most prevalent atmospheric pollutant. Most air contains some particulate matter, in varying quantities to at least hundreds of particles per cubic centimeter. However, in urban areas, these particles increase to such levels that they become a nuisance and hazardous to the health of the people that breathe them.

The value function (Fig. 39) is based on the 24 hr mean for particulate matter in micrograms per cubic meter ($\mu\text{g}/\text{M}^3$). The geometric mean of particulate matter in the Wichita Falls area for 1970 was $79 \mu\text{g}/\text{M}^3$, and $89 \mu\text{g}/\text{M}^3$ for 1971; for Abilene in 1971 it was $62 \mu\text{g}/\text{M}^3$; and Tyler's geometric mean for 1969 was $61 \mu\text{g}/\text{M}^3$. These regions are all given a category II rating by the Federal Register which is an intermediate rating between I (best) and III (worst) for particulate matter pollution.

Fig. 39 shows that concentrations up to approximately $25 \mu\text{g}/\text{M}^3$ have an EQ = 1.0. Assuming that the present level of particulate matter is $75 \mu\text{g}/\text{M}^3$ for the proposed reservoir area, then an EQ = 0.6 is given this parameter presently. Since particulate matter probably will increase with the reservoir, an EQ = 0.6 is assigned for project construction and use periods. Therefore, it is predicted that the Aubrey Reservoir Project will have no impact on the particulate parameter, thus, the impact in EIU = 0.

Photochemical Oxidants

Photochemical oxidants are usually expressed as ozone which is more easily measured than other oxidizing gas. These oxidants, in high enough concentrations, are detrimental to sensitive plants, and, they also contribute to smog formation.

The arithmetical mean for total photooxidants in Hunt County, Texas during a sampling period in 1971 was $16 \mu\text{g}/\text{M}^3$. Also, during 1971 in Dallas, the 1 hr maximum arithmetical mean was $43 \mu\text{g}/\text{M}^3$. Extrapolating either of these measurements for the Aubrey Reservoir area results in an EQ = 1.0 for this parameter. The value function graph (Fig. 40)

shows the curve that is used to develop the EQ for photo-oxidants in the environment.

The Aubrey Reservoir Project is predicted not to have any impact on the photochemical oxidants parameter, hence, the impact in EIU = 0.

Sulfur Oxides

Sulfur dioxide (SO_2) is the oxide of sulfur that is given the most consideration because of its corrosive abilities. Mixed with suspended particulate matter, SO_2 does have synergistic effects that are deleterious to health.

The maximum 24 hr concentration detected in Wichita Falls in 1971 was $40 \mu\text{g}/\text{M}^3$, with an arithmetic mean of $7 \mu\text{g}/\text{M}^3$. By converting the highest concentration of $40 \mu\text{g}/\text{M}^3$ to mg/l or ppm concentrations, one can use Fig. 41 to establish a measurement for SO_2 that could be extrapolated to this area. Since a concentration of 0.01 mg/l has to be reached before there is a decline observed in the environmental quality for sulfur oxides, an EQ = 1.0 is given this parameter for the present time.

There should not be an increase in the concentration of this gas in this area because industries which produce SO_2 probably will not develop in the area of the reservoir. Therefore, the Aubrey Reservoir Project will not have an impact on the sulfur oxides parameter, so, the impact is EIU = 0.

Others

The parameter others of the Air Pollution Category consists of all air pollutants that are not covered by the specific parameters. Data on air pollutants, with the exception of those previously discussed in this report, were not obtainable from any source that was contacted during this EES study of the Aubrey Reservoir Project.

The assumption is made that since the concentrations of the majority of the air pollutants are presently quite low, and that substantial evidence pertinent to this undefined group of substances is inadequate, then, an EQ = 1.0 can be assigned. Our prediction is that the Aubrey Reservoir Project will have no significant effect on this parameter, therefore, the impact in EIU = 0.

Land Pollution

Land in the Aubrey Reservoir area is used for agriculture, mining service, commerce, manufacturing, roads, utilities, industries, and residential and farmsteads. Each use of land has in some degree been mismanaged, and this has contributed to environmental pollution problems. In the land pollution study, two major categories are considered: changes in land use that result from the project and the way the project can affect the land quality through erosion.

Land Use

Land use in this parameter is grouped into two classes, developed and undeveloped lands. Developed lands in the Aubrey Reservoir Project area are those used for agriculture, mining, manufacturing, service, and commerce industries, roads, residential, and farmsteads. The undeveloped area is considered to be the area classed as natural and open space. The boundary used in this parameter is a line 0.5 mile in horizontal distance from the project boundary.

There are evidences of misused land. This is especially obvious in the eastern portion of the reservoir project associated with Eastern Cross Timbers. Here the soils "A" horizon was thin and due to other soil characteristics are easily eroded and leached. Much of this area was cleared of natural vegetation and placed in cultivation. Today, most of these lands are abandoned and are now old fields. Some areas in floodplains were put into crops, but there was the annual danger of flooding. There are evidences of improper cultivation practices.

Man has used areas for disposal of his solid waste, especially along the streams at road crossings. There are places called salvage yards of old automobiles scattered across the field, and they never appear to be in harmony with any landscape.

Portions of commercial fertilizers, pesticides, herbicides, and defoliant may adversely affect the natural food chain and life through water run-off.

Through mining operations, man changes the landscape. This may be in the production of petroleum and the removal of sand and gravel. There was no noticeable evidence of oil spillage in the Jacobs Oil Field. The worst offenders in mining are the pit mine operations for sand and gravel. The soil profile has been destroyed and overburden left in piles instead of being leveled once the mining operation has been completed. This type of land pollution leaves the area unusable.

The value function graph for Land Use (Fig. 42) is based on percentage of land developed in the area surrounding the proposed reservoir and the intensity of this development. On the graph the vertical or environmental quality axis is assigned values of 0 to 1.0, and the horizontal or percent of land developed axis is scaled from 0 to 100%. Also, included in the graph is the degree of development. This is expressed as high, medium, or low density of land development.

In order to make a land use judgment data were obtained from USGS 7.5 minutes series topographic maps and general highway county maps, as well as air photos of the area and field studies.

The area under consideration is rural, with most of the land use devoted to agriculture, primarily grazing with some crops. Other uses, which are minor, are mining of sand and gravel, garage, development project of housing and recreation on Persimmon Creek (tributary of Elm Fork) which is known as Pioneer Valley. The southwest part of Tioga is near the one-half mile boundary and also the northwest part of Pilot Point. Within the 0.5 mile of the proposed reservoir boundary the amount of developed land is estimated to be 93%. When compared to density of land development in urban and rural-urban fringes of north central Texas, the density in the reservoir area is low. Therefore, the density of land development is assigned a low value. A relative importance of 1.0 is assigned to the reservoir site. For the time phase of the project, the values of RI = 1.0 without the project and 0.25 for construction period and 0.75 for the use period.

During construction the land use will remain much the same as present development. But with the use period, the percentage of use is estimated to increase slightly and the density of use will rise to medium value. Within the 0.5 mile zone surrounding the reservoir project there will be a build up of housing and recreation with a slight build up of

service and commerce industries. Based on land use changes around other reservoirs in the north central Texas region, it can be anticipated that several hundreds of houses will be constructed, several million persons will be attracted for recreation annually, small retail establishments will be operated, and boat storage facilities will be provided. A value of 95% land use development is estimated for the use period of the reservoir.

Input of the above considerations into the worksheet-matrix and the following calculations yielded a total impact index of the Aubrey Reservoir Project of -5.88 EIU on land pollution due to use.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0 \times 0) + (1 \times 93) + \\ \text{Project} &\quad (0 \times 0)) = 93\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.25((0 \times 0) + (1 \times 93) + \\ \text{Construction Period} &\quad (0 \times 0)) = 23.25\% \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.75((0 \times 0) + (1 \times 95) + \\ \text{Use Period} &\quad (0 \times 0)) = 71.25\% \end{aligned}$$

Total weighted parameter estimate with project = 94.50%.

For this parameter the EQ determined from Fig. 42 is:

$$\text{"Without" EQ} = 0.82$$

$$\text{"With" EQ} = 0.40$$

Therefore, the environmental impact on Land Pollution from land use is

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.4) - (14 \times 0.82) \\ &= (5.60) - (11.48) \\ &= -5.88 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.4 - 0.82}{0.82} \times 100 \end{aligned}$$

$$= -51.22\% \quad \text{which is a "Major Red Flag".}$$

Soil Erosion

Soil erosion is another agent by which the Aubrey Reservoir Project can affect the environmental quality of the area. Erosion is a natural process always acting at varying degrees. Regardless of the rate, it is always effective. Man has the opportunity to control the rate of erosion; with types and methods of land use he can slow down or speed up the erosion process.

Soil erosion is generally defined as the loosening and removal of rock materials at the earth's surface by any process. In the Aubrey Reservoir area the forces or agents are running water and, to a lesser extent, wind. Erosion is a constructive as well as a destructive phenomenon. Through erosion, transportation, and deposition, unconsolidated mineral parent materials are accumulated. Many acres of agricultural lands in the Aubrey Reservoir area are on alluvial soils and young soils developing on alluvium.

Generally in agriculture and soil science the term erosion is used in a restricted manner. In these fields soil erosion is often used for accelerated erosion resulting from disturbance of the natural land, usually by man. This is in contrast to the natural process of erosion that takes place in the undisturbed land. In the Aubrey Reservoir area, the accelerated erosion can result from the exposure of the soil to runoff and wind through tillage, overgrazing, forest cutting, burning, and construction work. Any of these destroys or weakens the vegetation so that the exposed soil may erode rapidly if not properly managed.

There are many evidences of soil erosion, both gully and sheet, by running water and wind in the area. Especially in the Cross Timbers are many areas where the horizon "A" has been removed. Gullying occurs in now abandoned cultivated fields, and alluvial deposits occur in the floodplains. Most evidence of wind erosion occurs where soils have been blown from cultivated fields and deposited along fence rows. Due to differences in physical characteristics of the soils that have developed on the Grand

Prairie from those of the Cross Timbers, erosion has probably not gone on as rapidly on the Grand Prairie. But erosion processes have been in operation through the Elm Fork of the Trinity drainage basin.

Other erosion occurs along the roads, especially those covered with earthen materials and having little vegetation along the drainways. Then there is some erosion caused by the removal by man of topsoil, sand, and gravel.

The function graph for soil erosion (Fig. 43) is designed to express the environmental quality in relation to the sediment yields. The EQ axis indicates values from 0 to 1. Along the sediment yield (horizontal) axis, the erosion classes of none, slight, moderate, and extensive are used as a basis for eroded phases. Sediment yield values of each eroded phase are expressed in acre feet per square mile per year. The following values are associated with each descriptor:

| <u>Sediment Yield</u> <u>Acre-ft/sq mile/year</u> | <u>Descriptor</u> |
|--|-------------------|
| 0 | None |
| 0.5 | Slight |
| 1.0 | Moderate |
| 3.0 | Extensive |

Soil erosion is evident from observing the stream patterns on the topographic maps, viewing air photos, having some knowledge of erosion processes, and direct observation in the field. Determining the rate of erosion is more difficult. The Soil Conservation Service in Denton did have the needed erosion information. The northern portion of Denton County is just now being surveyed and mapped for soils and their characteristics. To determine the sediment yield, data from the Corps of Engineers estimate sheet was used. The 100 year sediment deposition was estimated to be 54,600 acre feet of sediment from a drainage basin covering 692 square miles. From this data, the sediment yields were calculated to be 0.789 acre-feet/sq mile/year.

In the worksheet-matrix spatial patterns of upstream, site, and downstream were given RI values of 0.33 each. For time distribution, without the project, an RI = 1.0 is

given; with project construction, an RI = 0.25 and project with use an RI = 0.75.

Without the project, the rate of erosion upstream, site, and downstream is assumed to be approximately the same, so each was given the calculated sediment yield 0.789 acre-feet/sq mile/year. During construction, there is no apparent reason for the upstream and downstream erosion rate to change appreciably from erosion rates without the project. So they have been assigned 0.789 acre-feet/sq mile/year. But, during construction in the reservoir site project boundary there will probably be an increase in soil erosion. This will be due to removal and destruction of vegetation and loosening of the mantle materials with the construction operation. Therefore, the site area is given a value of 0.9 acre-feet/sq mile/year. During the use period it is anticipated the upstream erosion will remain at approximately 0.789 acre-feet/sq mile/year. With proper control of land use in the project area, there should be a decrease in the project site area. Present cropping activities will be eliminated, allowing the return of natural vegetation. Some of the areas may be leased for grazing, but grazing can be controlled. Recreation activities could cause increased erosion in some areas. This is estimated to be 0.6 acre-feet/sq mile/year. Downstream, because of the flood control aspect of the reservoir, there should be a slight decrease in erosion. The rate is placed at 0.7 acre-feet/sq mile/year.

Input of the above mentioned considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project to +1.82 EIU on the Soil Erosion parameter.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0.33 \times 0.789) + (0.33 \times 0.789) + \\ \text{Project} &\quad (0.33 \times 0.789)) = 0.789 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.25((0.33 \times 0.789) + (0.33 \times 0.9) + \\ \text{Construction Period} &\quad (0.33 \times 0.789)) = 0.204 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.75((0.33 \times 0.789) + (0.33 \times 0.6) + \\ \text{Use Period} &\quad (0.33 \times 0.7)) = 0.517 \end{aligned}$$

Total weighted parameter estimate with project = 0.721.

For this parameter the EQ determined from Fig. 43 is:

"Without" EQ = 0.58

"With" EQ = 0.71

Therefore, the environmental impact on Soil Erosion is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (14 \times 0.71) - (14 \times 0.58) \\ &= (9.94) - (8.12) \\ &= +1.82 \end{aligned}$$

Noise Pollution

Noise pollution has increasingly become an environmental stress and worthy of special consideration in impacts of water resource projects. In general, reservoirs attract urbanization and developments along or near their shores.

Noise

Noises are undesirable sounds that have a psychological or physiological effect on man or other organisms. The Aubrey Reservoir site lies near approach and departure paths of aircraft using Love Field in Dallas, ca. 35 miles south; consequently a moderate amount of aircraft noise is present on the site area. This should increase when the Dallas-Fort Worth Regional Airport, near Irving, Texas, opens in 1973.

A minor source of noise, which could be interpreted as detracting from the wilderness/isolation atmosphere of the area, is the occasional exhaust noises from tractors and other farm equipment. This will be replaced and slightly increased by outboard motors and other recreational noises resulting from the anticipated recreational development of the area. Also, noises will become more frequent on more sites (disregarding the aircraft noises which are unrelated to the project). Development will conceivably also increase access to the area, leading to increased exhaust noises from automobiles and other recreational vehicles.

All spatial consideration is given to the site area (RI = 1.0); only increased access would have bearing on upstream-downstream effects, and drainage characteristics of the area suggest that the most feasible access will be on east-west routes transverse to the site area. Construction RI is valued at 0.2, with major weight (RI = 0.8) given to the use phase.

The present noise level is set at 70 dD(A) on the Infrequent/Sparse line (Fig. 44), with an anticipated increase to 80 dD(A) on the Frequent/Few Sites line during construction. Outboard and vehicle noises are anticipated to be moderate (75 dD(A)) during the reservoir use phase.

Input of these data into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -1.52 on Noise Pollution.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0((0 \times 70) + (1.0 \times 70) + \\ \text{Project} &\quad (0 \times 70)) = 70 \text{ dD(A)} \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.2((0 \times 70) + (1.0 \times 80) + \\ \text{Construction Period} &\quad (0 \times 70)) = 16 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With Project} &= 0.8((0 \times 70) + (1.0 \times 75)* + \\ \text{Use Period} &\quad (0 \times 70)) = 60 \end{aligned}$$

*Because of the variation in frequency and location of noises, and commensurate value functions (Fig. 44) weighted EQ's with project were totaled in final calculations, rather than summing the weighted intensity levels before EQ interpretation. Therefore, $1.0 \times 80 = 0.25 \text{ EQ}$ and $1.0 \times 75 = 0.21 \text{ EQ}$; and the weighted EQ's are calculated as:

Weighted EQ With

$$\text{Project-Construction} = (0.25 \times 0.2) = 0.05$$

Weighted EQ With

$$\text{Project-Use} = (0.21 \times 0.8) = 0.168$$

Total weighted EQ with project = 0.218.

For this parameter the EQ determined from Fig. 44 is:

"Without" EQ = 0.6

"With" EQ = 0.218

Therefore, the environmental impact on Noise Pollution is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (4 \times 0.218) - (4 \times 0.60) \\ &= (0.87) - (2.4) \\ &= -1.53 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.218 - 0.60}{0.60} \times 100 \\ &= -38\% \quad \text{which is a "Major Red Flag"}. \end{aligned}$$

Esthetics

This category contains six components and 17 parameters. These were selected by Battelle-Columbus for the EES because they capture those environmental elements which give some sensory pleasure to the majority of people. Esthetic value is relative to the observer's previous sensory preceptions, education and "sensitivity". Since water resource projects modify the environment, they have an impact on elements which are pleasing to peoples' senses. The objective of this category in the EES is to quantify this impact.

The importance of maintaining esthetically pleasing "natural" environments is obvious; with increasing urbanization, pressures of overcrowding and reduced work-week, people will make greater demands on "natural" environments. Esthetically pleasing environments offer escape from tensions of modern urban living.

Since the proposed Aubrey Reservoir site is located close to large metropolitan areas of Dallas-Fort Worth-Denton, the esthetics of the area are extremely important and must be considered in the planning, construction and use of the reservoir.

Land

The topography of the land on which water resource projects are constructed plays a major role in determining impact of the project on the esthetics. A reservoir situated on flatlands is scenically less attractive than one nestled in high mountains. However, the flooding of deep valleys or canyons may destroy scenic beauty already in existence. Thus, the act of flooding a mountain valley or canyon is likely to be rated negatively in respect to esthetics. Yet, the lake produced will have a much higher esthetic rating than a lake of similar size created upon relatively flat lands. Likewise, the nature of surface material adjacent to project structures may determine their overall esthetic impact.

Geological Surface Materials

The esthetic quality of land is enhanced by unusual coloration and diversity in types and texture of its component materials. When the Aubrey Reservoir site is compared to such places as the Grand Canyon, Painted Desert, White Sands or Wingate Sandstone it would be far inferior. Keeping this in mind, perhaps a flat coastal marsh is an exposure of geologic surface material that is less pleasing esthetically than the Aubrey Reservoir site.

The entire area of the proposed site was studied using geological maps and publications, and a field map drawn of the surface exposures on the USGS topographic sheets (7.5 minute series). This enabled the observer to go into the field and make on-site checks of the formations in respect to the projected lake levels and the types of outcrops that would occur at the various places over the proposed site. The western portion is situated on lower Cretaceous materials that are mainly made of thin beds of limestone interbedded with layers of clays, marls and limited sandstone. The eastern portion, along Isle du Bois and its tributaries, is underlain by materials of the upper Cretaceous Woodbine sandstone. Large quantities of sands and gravels that were deposited during the Pleistocene are exposed along the sides of the valleys as terraces. The lower flood plains, composed of silts and sediments of recent alluvium, form mud flats when covered during high water.

The upstream, site and downstream are underlain by the same types of surface materials and are given equal relative importance of 0.33 in spatial relationship. After considering the importance of the surface materials on a scale of 0 (coastal marshes) to 10 (Grand Canyon, etc.), (Fig. 45) a value parameter of 3 was assigned for each cell without the reservoir. The same values were retained for the construction period (5 years) since there would be little change in the geologic surface materials during this period. In 20 years there should be no change in the surface materials in the upstream and the downstream but there would be definite changes within the reservoir. These changes would be caused by waves striking the shoreline and

revealing geological formations; cutting landforms such as the wave cut cliffs; wave cut terraces; the production of wave built terraces; and formation of deltas and lacustrine plains in the upper areas of the lake that would be exposed during the time of low water stages. The change would not be great but would elevate the rated value of the cell from 3 to 4.

The time RI was assigned a value of one. The construction period RI was set at 0.25 since this is 25% of the 20 years from beginning of construction through the 15 years of use considered here. Therefore, $RI = 0.75$ was given to the use period.

Input of these data into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +0.36 EIU on Geological Surface Material.

Weighted Parameter
 Measurement Without Project = $1.0((3 \times 0.33) + (3 \times 0.33) + (3 \times 0.33)) = 2.97$

Weighted Parameter
 Estimate With Project-Construction = $0.25((3 \times 0.33) + (3 \times 0.33) + (3 \times 0.33)) = 0.74$

Weighted Parameter
 Estimate With Project-Use = $0.75((3 \times 0.33) + (4 \times 0.33) + (3 \times 0.33)) = 2.48$

Total weighted parameter estimate with project = 3.22.

For this parameter the EQ is:

"Without" EQ = 0.14
 "With" EQ = 0.20

Therefore, the environmental impact on Geological Surface Materials is:

$$\begin{aligned} EIU &= (PIU \times EQ_{with}) - (PIU \times EQ_{without}) \\ &= (6 \times 0.20) - (6 \times 0.14) \\ &= (1.2) - (0.84) \\ &= +0.36 \end{aligned}$$

Relief and Topographic Character

The Aubrey Reservoir site is located in the physiographic sub-regions of the Grand Prairie and the Eastern Cross Timbers. These are plains which show limited relief and topographic character as compared with mountains or hills, therefore, they have much lower relative esthetic value; but a higher esthetic value than the flat coastal plains of Texas. Esthetic value of an area is often determined by comparison with surround areas. In the case of the Aubrey Reservoir site good roads in the upstream and downstream areas will enable visitors easy access for comparison.

Five locations were used to determine the Relief and Topographic Character: 1) Upstream along the 33° 32' 30" North Latitude along the Elm Fork, 2) Downstream along the old Denton-Aubrey road, 3) Along the Sanger-Pilot Point FM road #455 crossing the major protion of the proposed lake site, 4) Along Elm Fork east of Valley View and 5) Along Stirrup Factory road west of Tioga on the Isle du Bois arm.

The selection of parameter values were made by revising the value function of the Battelle EES (Fig. 46) using tens instead of hundreds of feet in elevation and classifying all of the readings as smooth. The present area without the project and both phases with the project (construction and use) were considered as evaluations were made by extensive driving within the areas and by the study of the USGS topographic maps. The sites and elevations with their differences without and with the project with their assigned values follow:

| SITE | Minimum Elevation (feet) | Maximum Elevation (feet) | Difference (Relief) (feet) | Assigned Value |
|-------------------------------------|--------------------------------|--------------------------------|----------------------------------|-------------------|
| Upstream same with and without | 650 | 740 | 90 | 90 |
| Downstream same with and without | 540 | 570 | 30 | 30 |

| SITE | Minimum Elevation (feet) | Maximum Elevation (feet) | Difference (Relief) (feet) | Assigned Value |
|----------------------------|--------------------------------|--------------------------------|----------------------------------|-------------------|
| Sanger-Pilot Point Road | | | | |
| Without project | 572 | 735 | 163 | 100 |
| With project | 640 | 735 | 95 | 95 |
| Elm Fork | | | | |
| Without Project | 610 | 670 | 60 | 60 |
| With Project | 640 | 680 | 40 | 40 |
| Isle du Bois | | | | |
| Without Project | 590 | 680 | 90 | 90 |
| With Project | 640 | 680 | 40 | 40 |

The same values for the construction period as the "without" were used since there is usually a 5 year period for the building and filling of the lake.

Within the spatial rating of relative importance, upstream was given a value of RI = 0.10 on the basis of visitors in the area who are enroute to the lake or from the lake will note the appearance of the deeper valleys, the higher divides and the greater slope. The old Denton-Aubrey road is in a fairly wide flood plain and is heavily traveled. Visitors going to or from the lake will note the flatness of the valley and compare it to the lake site itself. A RI = 0.05 was assigned to the below site. The site itself will have the greatest relative importance, therefore RI = 0.85 was given to this spatial frame.

RI values of 0.25 and 0.75 were given to the construction and use periods respectively because of their relative durations.

Input of these data and consideration into a worksheet-matrix and calculation below yielded a total impact index of the Aubrey Reservoir Project of 0 EIU on Relief and Topographic Character.

Weighted Parameter

Measurement Without = $1.0((9 \times 0.10) + (8.66 \times 0.85) + (3 \times 0.05)) =$
Project 8.41

Weighted Parameter

Estimated With = $0.25((9 \times 0.10) + (8.66 \times 0.85) + (3 \times 0.05)) =$
Project-Construction 2.1

Weighted Parameter

$$\text{Estimated With} = 0.75((9 \times 0.10) + (8.66 \times 0.85) + (3 \times 0.05)) = 6.31$$

Total weighted estimate with project = 8.41

For this parameter EQ determined from Fig. 46 is:

"Without" EQ = 0.02

"With" EQ = 0.02

Therefore, the environmental impact on Relief and Topography is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (16 \times 0.02) - (16 \times 0.02) \\ &= (0.32) - (0.32) \\ &= 0. \end{aligned}$$

Width and Alignment

The proportion of the width of a canyon or gorge to its depth (measured from the highest surrounding points to the valley floor) and the deviation of a watercourse from a straight line have a direct bearing on the esthetic quality of a valley or stream. Although esthetic value decreases with the increase in cross section and decrease in depth, there is still esthetic value in wide, shallow valleys. The area of the proposed site of the Aubrey Reservoir is in a region of rolling plains where the streams seldom cut a valley more than 50 feet below the flood plain. Most of the valleys are 10 or more times greater in width than depth.

As the reservoir fills, the valleys will become more shallow and their alignment will change. At present the area has several streams converging just above the dam site. When formed, the lake will have several arms that will occupy these stream valleys and give character to the alignment of the lake. The parameter values for computing the EQ are zero for upstream and downstream, whereas the

site has a value of three. During the 5 year period some filling will slightly increase the esthetic value and change the parameter measure to four. During the use phase, the lake will spread out giving varied alignment adding more to the esthetic value and increasing the parameter value to five.

An RI of 1.0 was assigned to the site since upstream and downstream will not be affected. Since a change would take place during the construction period an RI = 0.25 was assigned to this time frame. The greater RI = 0.75 was assigned to the use period.

Input of these data and consideration into a worksheet-matrix and calculations below yield a total impact index of the Aubrey Reservoir Project of +1.24 EIU on Width and Alignment.

Weighted Parameter

Measurement Without = $1.0 ((0 \times 0) + (1.0 \times 3) + (0 \times 0)) = 3.00$
Project

Weighted Parameter

Estimate With = $0.25 ((0 \times 0) + (1.0 \times 4) + (0 \times 0)) = 1.00$
Project-Construction

Weighted Parameter

Estimate With = $0.75 ((0 \times 0) + (1.0 \times 5) + (0 \times 0)) = 3.75$
Project-Use

Total weighted estimate with project = 4.75.

For this parameter the EQ determined from Fig. 47 is:

"Without" EQ = 0.19

"With" EQ = 0.314.

For conversion to EQ units, it was necessary to modify the Battelle value function (Fig. 47) for the Aubrey Reservoir area. All EQ's were determined from the lowest curve of Fig. 47. Therefore, the environmental impact on Width and Alignment is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.314) - (10 \times 0.19) \\ &= (3.14) - (1.9) = +1.24. \end{aligned}$$

Air

Esthetics related to air are based, in part, upon the quality of sounds and odors carried by the air; and its clearness.

Odor and Visual Quality

The types of odors and visual stimuli in an area are an important aspect of the esthetic quality of the environment. Visitors to an area are quick to note any unpleasant qualities which detract from their enjoyment. Suspended particles and visible gases, are probably the primary source of unpleasant odors and visual stimuli, while pleasant odors and visual stimuli result from the presence of wild flowers, evergreen trees, and occasionally agricultural practices (new-mown hay, etc.).

The odor and visual quality of the reservoir site was established from several hours of observation on the area to be inundated. A comparison of the observations with those previously made on other natural areas was used to determine the quality measure of this parameter. Visual quality was classed under the categories: Heavy, Frequent Pollution; Moderate, Occasional Pollution; Clear, No Pollution. Odor quality was classed as Disagreeable Odor, Lacking Odor, or Pleasant Odor.

The areas upstream and downstream from the site will be affected little by construction or use and are given a spatial RI value of 0. During construction, odor and visual quality will decrease little and this phase is also weighted as 0.

As calculated below, the current visual quality is considered clear, no pollution, and high odor quality. This results in an EQ of 0.90. No significant change in this parameter is expected with construction of the reservoir. Therefore, impact EIU = 0.

Sounds

The types of sounds, both pleasant and unpleasant, in an area add to the esthetics of the environment.

The potential recreational use of the Aubrey Reservoir will include boating, fishing, camping and nature hikers. Visitors to the reservoir will undoubtedly be quick to note any pleasant or unpleasant sounds which will add or detract from their enjoyment of the area, and, because many people are seeking areas which provide solitude and serenity, sounds are an important aspect of environmental quality.

Pleasant sounds include bird songs, calls of frogs, toads, and insects, and movement of water on a lake shore. Unpleasant sounds result from motor vehicles, farm implements, motor boats, and other human activity.

The serenity of the reservoir site was established from several hours of observation on the area to be inundated. A comparison of these observations with those previously made on other natural areas was used to determine the sound quality of the proposed reservoir site. Sound quality on the area was classed under the following categories: Frequently Unpleasant, Occasionally Unpleasant, Occasionally Pleasant, Frequently Pleasant. The areas upstream and downstream from the site will be affected little by construction or use and are given a spatial relative importance of 0. During construction, sound quality will decrease, and during use, motor vehicles and motor boats will decrease, and during use, motor vehicles and motor boats will detract. These phases are given equal relative importance values of 0.5.

As calculated below, the sound quality is currently considered to be Occasionally Pleasant with an EIU of 1.1. Sound quality on the proposed site is currently enhanced by bird songs, frog calls, insects and an overall quietness. A few motor vehicles and farm implements sometimes detract. During construction, sound quality will decrease to Occasionally Unpleasant with an EIU of 0.1. During the use period, increased utilization of the reservoir for recreational purposes will create unpleasant sounds with an EIU of 0.1.

Weighted Parameter

Estimate Without = $1.0((0 \times 0.55) + (1 \times 0.55) + (0 \times 0.55))$
Project = 0.55

Weighted Parameter

Estimate With = $0.50((0 \times 0.55) + (1 \times 0.10) + (0 \times 0.55))$
Project-construction = 0.05

Weighted Parameter

Estimate With = $0.50((0 \times 0.55) + (1 \times 0.1) + (0 \times 0.55))$

Project-Use = 0.05

Total weighted estimate with project = 0.10

For this parameter the EQ determined from Fig. 49 is:

"Without" EQ = 0.55

"With" EQ = 0.10

Therefore, the environmental impact on Sounds is:

$$EIU = (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}})$$

$$= (2 \times 0.10) - (2 \times 0.55)$$

$$= (0.20) - (1.10)$$

$$= -0.90$$

$$\% \text{ change EQ} = \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100$$

$$= \frac{0.55 - 0.10}{0.55} \times 100$$

$$= -80\% \text{ which is a "Major Red Flag."}$$

Water

The esthetic quality of the water resource project itself must be considered as an important environmental component. The esthetics of a body of water are captured in the following parameters.

Appearance of Water

The esthetic appeal of water in a landscape is largely visual. This appeal will be heightened if the water is clean and clear in appearance and decreased if the water is turbid, off-color, or opaque. Turbidity in natural waters results from suspended materials in the water. The suspended materials are usually silt, clay, pollutants, or algal cells.

Moving water is usually more appealing to the eye than still or sluggish water. A tumbling brook has more esthetic appeal than a slow-moving stream resembling a long, sluggish canal.

When these two factors are combined they account for most of the visual esthetic appeal of a body of water. The two factors are combined into a three-stepped value function graph in the Battelle EES (Fig. 50). The clarity of the water is represented by curves at clear, moderately turbid, and turbid levels. The flow characteristics of water are represented by the abscissal scale of static, slow, moderate, and white water.

Elm Fork, Isle du Bois, Spring Creek, and the other principal streams of the reservoir area are all rather sluggish streams draining agricultural lands. Since the mean turbidity of these streams appear to be 100 - 200 JTU (see Turbidity Parameter report), we classified both the streams and ponds of the area as slightly more than moderately turbid. Current speed was assessed as slow (0.25 - 2.25 ft/sec) according to Fig. 50. Consequently, we derived an EQ value of 0.40 for the upstream, reservoir site, and downstream areas without the project.

During the construction of the dam it is expected that the turbidity of streams and ponds in the upstream area will remain the same while at the reservoir site and downstream it will increase. Therefore, we have estimated that EQ values in these two areas will decline to 0.20.

Input of these data into a worksheet-matrix led to the following calculations:

Weighted Parameter

Measurement Without = $1.0((0.4 \times 0.4) + (0.6 \times 0.4) + (0.2 \times 0.4))$
Project = 0.40

Weighted Parameter

Estimate With = $0.2((0.4 \times 0.2) + (0.6 \times 0.2) + (0.2 \times 0.2))$
Project-Construction = 0.048

Weighted Parameter

Estimate With = $0.8((0.2 \times 0.4) + (0.6 \times 0.45) + (0.2 \times 0.65))$
Project-Use = 0.384

Total weighted parameter estimate with project = 0.432.

For this parameter the EQ as measured in Fig. 50 is:
"Without" EQ = 0.400
"With" EQ = 0.432

Therefore, the environmental impact on the Appearance of Water is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.432) - (10 \times 0.40) \\ &= (4.32) - (4.00) \\ &= 0.32. \end{aligned}$$

Land and Water Interface

The land-water interface of multi-purpose reservoirs often present significant esthetic problems. When the water level of a reservoir fluctuates severely each year, it will result in the exposure of unsightly mud flats which may dry, crack, and give rise to rank growth of noxious weeds before being flooded again. Access to the water may become difficult if boat ramps, piers, and walkways are stranded above the waterline.

The water level of most streams, small stock tanks and reservoirs already in the area fluctuate markedly with the seasons. In late winter and spring water levels are up while during the summer months water levels recede gradually. As a result there are some unsightly mud bands exposed. If cattle are watering at the edge of the stream or pond the mud is made even more unsightly. Consequently, without the project we judged the present influence of water level fluctuation on the esthetics of the area to be moderately severe (EQ = 0.30, Fig. 51) in the upstream, reservoir site, and downstream areas.

During the construction period water level fluctuations are not expected to change in stock tanks and small reservoirs in the area. While construction activities may cause some minor fluctuations in the water level of Elm Fork, no major affect on the land-water interface is anticipated and so we have assigned EQ values of 0.30 to all three spatial divisions of the area during construction.

In the use phase of the reservoir's life no change in water level is anticipated in the upstream area. In the reservoir site water level fluctuations will be severe and we anticipate that mud flats will be exposed to view from time to time as they are in other area reservoirs (Garza-Little Elm, Grapevine, Bridgeport, etc.). Therefore, we extracted an EQ value of 0.2 for the reservoir site from the value function curve (Fig. 51).

We also anticipate that the installation and operation of the Aubrey Dam will result in a stabilized flow of water downstream. This stabilization of flow coupled with the expected increase in water quality below the dam should allow for the accumulation and exposure of a more permanent substrate in the downstream portion of Elm Fork. We expect that a substrate of sand and gravel will permanently replace much of the silt which forms the stream bed in many areas today. Consequently, we predict an improved land-water interface in the downstream area (EQ = 0.40).

Input of these data into a worksheet-matrix led to the following calculations:

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Measurement Without} \\ \text{Project} \end{array} = 1.0((0.20 \times 0.30) + (0.70 \times 0.30) + (0.10 \times 0.30)) = 0.30$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Construction} \end{array} = 0.2((0.20 \times 0.30) + (0.70 \times 0.30) + (0.10 \times 0.30)) = 0.06$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Use} \end{array} = 0.8((0.20 \times 0.30) + (0.70 \times 0.20) + (0.10 \times 0.40)) = 0.192$$

Total weighted parameter estimate with project = 0.252.

For this parameter the EQ is:

"Without" EQ = 0.300

"With" EQ = 0.252

Therefore, the environmental impact on Land and Water Interface is:

$$EIU = (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}})$$

$$\begin{aligned}
&= (16 \times 0.252) - (16 \times 0.300) \\
&= (4.03) - (4.80) \\
&= -0.77.
\end{aligned}$$

Odor and Floating Materials

Most people feel that the inclusion of water, still or running, adds to the esthetics of an outdoor scene. However, the visual appeal of a body of water can sometimes be diminished if when the observer approaches the shore he encounters a variety of noxious odors or unpleasant floating materials.

In the Battelle EES, the value function graph (Fig. 52) consists of three curves for 1) lacking odor, 2) noticeable odor, and 3) disagreeable odor. Each of these three curves decreases in environmental quality as the amount of floating materials increases from none to heavy.

In the course of this study, we made dozens of trips to the reservoir area and spent many hours on all streams and many of the farm ponds and stock tanks in the area. In our judgement, both the streams and ponds of this area have at present a noticeable, although not objectionable odor. Some exceptions to this generalization were encountered during several float trips down Elm Fork and Isle du Bois Creeks when the canoe passed an occasional dead cow in or near the streams. Also, Elm Fork received the treated sewage effluent of Gainesville, Texas, and for the first 2-3 miles below the town the stream does have an objectionable odor. However, through natural self-purification processes the odor-causing materials have been degraded before they reach the reservoir site. Between the proposed dam site and the upper end of Garza-Little Elm Reservoir, Elm Fork becomes a rather sluggish stream. In this section of the river algae blooms do occur and in the summer the stream may take on a soupy-green appearance and have an offensive odor.

The presence of floating materials - plant debris, trash, cans and bottles, scum, and petroleum products - reduce the esthetic value of any body of water. Most of the streams in the project area are small, slow-moving, and flow through heavily-settled rural areas. Local residents

are often prone to use the nearest bridge as a handy place to dump trash, garbage, used appliances, etc. Natural debris is contributed by the streamside forests. In one 8 mile long section of Elm Fork between highway 455 and highway 377 we counted seven large log jam obstructions across the stream. Each of the obstructions had accumulated a large quantity of unsightly floating debris and trash.

Consequently, in our judgement the amount of floating materials at present is moderate throughout the area.

During construction period of the reservoir it is expected that the odor and floating materials present will not change in the upstream area. Within the reservoir basin and downstream from the dam the amount of floating materials (brush, construction debris, oil and gasoline from machinery) will increase.

During the use period odors from the reservoir will probably remain at a noticeable but not objectionable level. Other reservoirs in this area (Garza-Little Elm, North Lake, Grapevine, Moss Lake) do not present significant odor problems. Floating materials will probably not be a problem in the new reservoir judging from experience with other reservoirs in the North Texas area. In fact, the large open-water areas will present a broad expanse of clear water to the eye, and so the reservoir will enhance this parameter. Elm Fork below the dam will be clearer, cleaner, and less odoriferous than it is now leading to an enhancement of environmental quality in this area as well.

In calculating the impact on this parameter we assigned RI values of 0.20, 0.70, and 0.10 to the upstream, reservoir site, and downstream areas, respectively. The construction period was given an RI value of 0.10 while the use period RI was 0.90. Input of these data and consideration into a worksheet-matrix and calculations below yielded an impact of +0.84 EIU on Odor and Floating Materials.

Weighted Parameter

Estimate Without Project = $1.0((0.20 \times 0.41) + (0.70 \times 0.40) + (0.10 \times 0.39)) = 0.401$

Weighted Parameter

Estimate With Project-Construction = $0.10((0.20 \times 0.40) + (0.70 \times 0.30) + (0.10 \times 0.28)) = 0.032$

Weighted Parameter
 Estimate With = $0.90 ((0.20 \times 0.40) + (0.70 \times 0.60) +$
 Project-Use $(0.10 \times 0.65)) = 0.508$

Total weighted parameter = 0.54.

For this parameter the EQ determined from Fig. 52 is:

"Without" EQ = 0.40

"With" EQ = 0.54

Therefore, the environmental impact on Odor and Floating Materials is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (6 \times 0.54) - (6 \times 0.40) \\ &= (3.24) - (2.40) \\ &= 0.84. \end{aligned}$$

Water Surface Area

People have a natural attraction to water and its surface appearance. The movement of waves, the reflection of objects from its surface and the movement of sail boats or motor boats on the water all emphasize the esthetic quality of the water's surface.

The proposed Aubrey Reservoir site is in a region of dense population concentration, therefore, thousands of visitors each year will enjoy the lake and the recreation that can be obtained by visiting it. The proposed site is located in gently rolling plains with limited rainfall. The streams of the region are in general, situated in broad but shallow valleys, narrow and shallow with forest along their banks. All of the streams of the area are less than 50 feet wide during the normal flow but will vary from a few feet in the dry season to flood periods when they may become several hundreds of feet wide.

The main lake will form directly behind the dam with two major arms extending up Isle du Bois and Elm Fork valleys. The portion of the lake behind the dam will have a surface area of several miles of width.

The Battelle-Columbus system of rating of esthetic value of surface water is based upon the width of the lake (Fig. 53). The 620 foot contour line was used to determine the width for esthetic appreciation since the water level will be closer to this level far more often than the level of the flood pool. Comparisnal distances across the present water surfaces and projected surface with the reservoir, determined for four locations within the proposed reservoir site, are:

| <u>Site Location</u> | <u>Without Project Width (Feet)</u> | <u>With Project Width (620 Foot Elev.) (Feet)</u> |
|--|---|---|
| 1 - Along FM Road 455 Major Body of the Lake | under 50 | 26,250 |
| 2 - Elm Fork Branch Along County Line | under 50 | 6,000 |
| 3 - Isle du Bois Branch Along Stirrup Factory Road | under 50 | 3,750 |
| 4 - Buck Creek Along US 377 South of Tioga | under 50 | 875 |

The mid-point value for each of the divisions was determined from Fig. 53. The divisions in feet and the x-axis have been translated on a basis of 0 - 10, and the midpoint of each chosen for calculations. These are:

| <u>Divisions in Feet</u> | <u>Midpoint Value</u> |
|--------------------------|-----------------------|
| 0 - 300 | 1.25 |
| 300 - 1,000 | 3.75 |
| 1,000 - 5,000 | 6.25 |
| 5,000 - and up | 8.75 |

These median values serve as parameter measurements. The areas upstream will not be modified by the construction of the lake and were given RI values of zero. The without the project site measure is assigned a value of 1.25 since all four of the site locations are less than 300 feet wide and this is the average. The reservoir will begin to fill and there will be a considerable increase in the water surface area during the 5 year construction period. The width of the surface at the four sites were measured at the 620 foot contour and the median value of these measurements

was used as the parameter measurements: 8.75, 8.75, 6.25 and 3.75. The average of these, 7.25, was entered into the site cell of construction with project and the same entry was made for the use period. An RI of 1.0 was given to the site since the upstream and downstream are of no importance. The construction period carries an RI = 0.25 since there will be some fluctuation during the early stages of lake construction. The use period was given an RI = 0.75.

Input of these considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +5.99 EIU Water Surface Area Index (note: the parametric values represent means of several determinations).

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0 \times 0) + (1.0 \times 1.25) + (0 \times 0)) \\ \text{Project} &= 1.25 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.25 ((0 \times 0) + (1.0 \times 7.25) + (0 \times 0)) \\ \text{Project-Construction} &= 1.812 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.75 ((0 \times 0) + (1.0 \times 7.25) + (0 \times 0)) \\ \text{Project-Use} &= 5.437 \end{aligned}$$

Total weighted estimate with project - 7.249.

For this parameter the EQ determined by Fig. 53 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.125 \\ \text{"With" EQ} &= 0.724 \end{aligned}$$

Therefore, the environmental impact on Water Surface Area Index is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.724) - (10 \times 0.125) \\ &= (7.24) - (1.25) \\ &= +5.99 \end{aligned}$$

Wooded and Geologic Shoreline

Visitors to lakes look at the shoreline and its appearance, the kinds and ruggedness of rock formations, its sandy beaches, and the surrounding vegetation. Each person has his own preference as to the type of shoreline which gives him pleasure. Most people derive considerable pleasure from wooded shorelines with outstanding geological structures.

The eastern two-thirds of the proposed Aubrey Reservoir site is in a region that is underlain by deposits of the Woodbine Sandstone. The western third adjacent to the Elm Fork of the Trinity River is underlain by a combination of the formations of the Denton, Paw Paw, Weno and Grayson deposits.

The Woodbine formation consists of soft sandstones that are cross-bedded and materials of sands, clays, and ferruginous materials. As the reservoir rises, wave action will cause the exposure of the harder sandstone formations, distribute the sands to form beaches and expose the clay.

The area of the Woodbine supports a dense growth of hardwood forest as its natural vegetation. Much of the region has been cut over as the land was developed agriculturally, but with the establishment of the lake the vegetation may again re-establish itself. We recommend that a zone around the lake be permitted to return to forest. This has been the case of the Garza-Little Elm Reservoir, a lake approximately 20 years old.

The Elm Fork arm of the proposed lake has been cut into a region of thin bedded limestone, marl and some thin beds of sandstone. Most of the region has been used for agriculture. The stream valleys are underlain by alluvial fill and some dissected Pleistocene deposits. They support a mixed lowland forest which is found only near the streams.

A judgment of the esthetic value of wooded and geologic shoreline in the proposed Aubrey Reservoir was made by visiting Garza-Little Elm Lake and Grapevine, which are on similar Woodbine **deposits** and are slightly more than 20 years old. Study of shorelines of these reservoirs included examination of the weathering of materials forming the shoreline, estimation of the per cent of rocky, sandy and dirt shoreline, and estimation of the extent to which the forest has returned to the lands adjacent to the lake. Aerial photographs of and field reconn-

aissance in the Aubrey Reservoir site enabled evaluation of the type of shoreline which will be produced.

The upstream and downstream areas of the Elm Fork will not be affected in shoreline change with the lake construction and were assigned $RI = 0$. The EQ with and without the reservoir was determined from Fig. 54 and based on the composition of shoreline materials of mud, or the combinations of sand, gravel and rock. The value of one was given for the without project since the lands would be the low flat alluvial materials adjacent to the streams, which are primarily fine muds when wet. The study of the areas up to 500 feet on either side of the stream revealed that there is from 30 to 60% coverage by forest. The site was given an $RI = 1.0$.

The lake basin will be at flood levels very few times. Therefore, the 620 foot contour is more appropriate in determining shoreline composition of forest and geological materials. An estimate of the forest covering was made from aerial photographs. Most of this region is used for agriculture or for pasture; only scattered clumps of hardwoods occur. The forest is estimated to cover less than 30% of the land. The geological surface map was utilized to determine the materials that will occur within 200 - 500 feet from the 620 foot contour interval. These materials were correlated with like materials found along the shores of Lakes Lewisville and Grapevine for determination of surface materials and vegetation. Much of this will have less than 30% coverage of forest, but since rocky terrain will be revealed a parameter estimate of 4 (20% sand and gravel rock) was assigned for the construction period. This period of 5 years was assigned an $RI = 0.25$.

Since exposure of the more resistant materials by wave action and run-off as well as establishment of beaches is expected, the shoreline and forests will increase in area (approximately 30 - 60%). A parameter estimate of 5 was made and an $RI = 0.75$ was given to the use period.

Input of these considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +5.42 on the Wooded and Geologic Shoreline index.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1 ((0 \times 0) + (1 \times 1.0) + (0 \times 0)) \\ \text{Project} &= 1.0 \end{aligned}$$

Weighted Parameter
 Estimate With = 0.25 ((0 x 0) + (1.0 x 4.0) + (0 x 0))
 Project-Construction
 = 1.0

Weighted Parameter
 Estimate With = 0.75 ((0 x 0) + (1.0 x 5.0) + (0 x 0))
 Project-Use
 = 3.75

Total weighted parameter estimate with project = 4.75

For this parameter, the EQ determined by Fig. 54 is:

"Without" EQ = 0.366
 "With" EQ = 0.908

Therefore, the environmental impact on Wooded and Geologic Shoreline index is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.908) - (10 \times 0.366) \\ &= (9.08) - (3.66) \\ &= +5.42 \end{aligned}$$

Biota

This component concerns the esthetic value of biota in the ecosystems within the reservoir site. Esthetic value of Biota concerns the sensory pleasure people derive from the presence of certain plants and animals. In general, mature climax associations are esthetically more pleasing than disturbed and/or successional stages.

Animals - Domestic

At present, density of domestic animals varies widely from scarce to abundant, depending on land use in and near the proposed Aubrey Reservoir site. On croplands used for winter

grains, the presence of cattle varies seasonally, with abundant populations during winter and none during the period May - November. Many domestic hay meadows sustain no grazing animals, and native grasslands are generally over-grazed, in some cases resulting in emaciated animals during winter, which are esthetically undesirable. Domestic bottomland pastures of coastal bermudagrass sustain large populations of cattle, up to one cow per 2 acres, in good condition the year round.

Inundation will exclude domestic animals from the immediate reservoir basin and recreational development should reduce or eliminate populations of public areas and smaller tracts bordering the reservoir. Larger tracts of adjacent, less fertile upland situations should sustain moderate, and generally pleasing levels of domestic cattle and horses.

It is difficult to interpret the EQ for domestic animals due to variations in present populations, possible aspects with which we view presence and abundance of domestic animals (i.e., setting desired such as pastoral, recreational, wilderness, etc.), and area delineation.

RI values of 0 were given to upstream and downstream categories, since they should be unaffected by the project. All the importance (1.0) is given to the site area which is considered here to include both the proposed reservoir basin and the adjacent border area. Temporal effects are considered to be immediate, at the onset of construction, since few domestic animal owners would leave animals on the construction site due to hazard of physical injury, reduced forage, downed fences, etc. Therefore, the total RI of 1.0 is given to 5 year or construction period.

Input of these data into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +2.5 EIU on the Domestic Animals. Note that values of 1, 2 and 3 are assigned as midpoints of the scarce, common and abundant categories respectively (Fig. 55).

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0 \times 2) + (1.0 \times 2) + (0 \times 2)) \\ \text{Project} &= 2.0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 1.0 ((0 \times 2) + (1.0 \times 1) + (0 \times 2)) \\ \text{Project-Construction} &= 1.0 \end{aligned}$$

Weighted Parameter
Estimate With = 0
Project-Use

Total weighted estimate with project = 1.0

For this parameter the EQ determined from Fig. 55 is:

"Without" EQ = 0.9
"With" EQ = 0.4

Therefore, the environmental impact on Domestic Animals is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (5 \times 0.4) - (5 \times 0.9) \\ &= (2.0) - (4.5) \\ &= -2.5 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.4 - 0.9}{0.9} \times 100 \\ &= -50\% \quad \text{which is a "Major Red Flag."} \end{aligned}$$

Animals - Wild

The presence of wild animals, mammals, birds, reptiles, amphibians, fish, and insects and other invertebrates add to the local color of an area. Observance of wild animals by amateur naturalists is increasing as an awareness of the "out-of-doors" becomes more prevalent today.

Wild animals currently present on the reservoir have been listed separately in a previous section. As listed, small mammals, especially rodents, are common, but not numerous, and most are nocturnal and not easily observed. Birds are common on the area and a wide variety can be observed during spring and fall migrations. Reptiles and amphibians are relatively rarer, but are easily observed at night during rainy periods. Aquatic forms, such as fish and aquatic insects, are not prevalent, but can be observed with some effort. There are

only a few white-tailed deer on the site, and these are rarely observed. No other large mammals are present.

The value function for wild animals is shown in Fig. 56 and the current abundance for small forms is considered common, while large animals are rare. No effect on wild animals is anticipated upstream from the site, while the fauna should be enriched downstream. This latter area is given a spatial RI of 0.25 while the site is given an RI of 0.75. Construction will cause some reduction in habitat and is given an RI of 0.25, while the use phase is given 0.75. Inundated areas will not be decreased in faunal richness because of the influence of an increase in aquatic organisms on the site and downstream from the reservoir. The site should be altered little in wild animals if one considers the area between the maintained lake level and the upper guide contour level that will not be constantly inundated.

As calculated below, a net loss of only 0.10 EIU is foreseen for the area. This loss is incurred only during the construction phase.

Weighted Parameter

$$\begin{aligned}\text{Measurement Without} &= 1.0 ((0 \times 0.55) + (0.75 \times 0.55) + \\ \text{Project} &\quad (0.25 \times 0.55)) \\ &= 0.55\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.25 ((0 \times 0.55) + (0.75 \times 0.45) + \\ \text{Project-Construction} &\quad (0.25 \times 0.55)) \\ &= 0.12\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.75 ((0 \times 0.55) + (0.75 \times 0.55) + \\ \text{Project-Use} &\quad (0.25 \times 0.55)) \\ &= 0.41\end{aligned}$$

Total weighted estimate with project = 0.53.

For this parameter the EQ determined from Fig. 56 is:

"Without" EQ = 0.55

"With" EQ = 0.53

Therefore, the environmental impact on Wild Animals is:

$$\begin{aligned}
 \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\
 &= (5 \times 0.53) - (5 \times 0.55) \\
 &= (2.65) - (2.75) \\
 &= -0.10
 \end{aligned}$$

Diversity of Vegetational Types

Types of vegetation and their proportions add to or detract from the esthetic quality of a site. Type classification is physiognomic: forest, moor, grazed fields, grassland, etc. Types are ranked in the EES; forest, for example, is rated higher than grassland. Also, type diversity is estimated and combined with type proportion. A 100% Post Oak Forest (high uniformity) would be of less esthetic worth than a mixed coniferous-hardwood forest. Fig. 57 shows the manner in which type and diversity are integrated.

Subjective measures were made as the vegetational types were sampled, gridded and structurally-defined (see report on Botanical Elements). Upstream, downstream and site observations were made at Prairie Grove and north of Green Valley.

Type selection was affected greatly by the extent of each type in the reservoir area. These acreages were:

| <u>Type</u> | <u>Acres</u> |
|---|--------------|
| Forest | 4,554 |
| Abandoned Old Field | 26,635 |
| Bare Cultivation | <u>3,861</u> |
| Total Reservoir at Upper Guide Contour | 35,050 |

Site type was selected from the X-axis of the function value graph (Fig. 57) as Type 2 (pre-dominately grass, dry-farming) with a diversification of 10%. Type 1 = no vegetation; Type 3 = cultivated (irrigated) crops; Type 4 = trees. Each type on the value function grades from 100% to a mixture of other types, with a commensurate increase in EQ.

Diversification selection was interesting in view of the history of diversification of the site. Prior to 1835, the vegetation consisted of deciduous streamside forest dominated

by hackberry and cedar elm on the floodplains of Elm Fork and Isle du Bois. Upland Post Oak Forest blanketed the remainder of the site with cedar elm, usually predominant along the drier and higher terraces of the floodplain, mixing with Post Oak along the intermittent branches and runs feeding the two larger streams. The area was a 100% uniform forest.

After 1835 as the forests were cleared for cultivation, fuel wood and construction timber, a third vegetational type, old field, appeared when upland cultivated areas became sterile and were converted to pastures. The forests gradually dwindled as a result of demands for fuel until gas became generally available for domestic use in the 1930's, and the pressure on them subsided. Thus, because of man's impact (disclimax) and the guidelines for this parameter in the EES, the site should have a higher EQ than if it were virgin climax vegetation. However, now, old field predominates and is very uniform because of heavy grazing.

Spatial RI's (0.33 for upstream, site and downstream) are based on the observations that vegetational types and their diversity are uniform on site and above or below the site. Time RI's (construction period = 0.4, use period = 0.6) reflect the diversification brought on by a stabilized downstream water table plus the addition in time of a new vegetational type, wetland or marsh in the upper third of the lake and around its margin. The wetland will diversify on the new lacustrine plain--creeping love grass, many perennials and finally pioneer floodplain forest of willow and cottonwood (this stage is presently not found on or near the site).

Input of the estimates and considerations into the worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of +0.5 EIU on Diversity of Vegetational Types.

Weighted Parameter

$$\begin{aligned} \text{Estimate Without} &= 1.0 ((0.33 \times 10) + (0.33 \times 10) + \\ \text{Project} &\quad (0.33 \times 10)) \\ &= 10 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.40 ((0.33 \times 15) + (0.33 \times 30) + \\ \text{Project-Construction} &\quad (0.33 \times 10)) \\ &= 7.3 \end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.60 ((0.33 \times 30) + (0.33 \times 50) + \\ \text{Project-Use} &\quad (0.33 \times 20)) \\ &= 19.8\end{aligned}$$

Total weighted parameter with project = 27.1

For this parameter the EQ determined from Fig. 57 is:

"Without" EQ - 0.35

"With" EQ = 0.40

Therefore, the environmental impact on Diversity of Vegetational Types is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (9 \times 0.40) - (9 \times 0.35) \\ &= (3.60) - (3.15) \\ &= +0.45\end{aligned}$$

Variety Within Vegetational Types

Degrees of variety within a vegetational type, as an esthetic rather than an ecological parameter, combines species diversity and rare and endangered species evaluations to determine the unusualness of an area. The importance of the parameter is that irreparable loss occurs if an unusual habitat or an unusual element, as a rare plant, is destroyed because of project construction.

Subjective estimations were made on upstream, downstream and site areas at the time the diversities of vegetational types were estimated. The vegetation was found to be uniform within the types. Compared to near-climax, the Post Oak Forest is unusually uniform. Competition is so severe in the arborescent layer that post oak ends up with all of the biomass, number of individuals and a good distribution. The lower layers are severely uniform because of extreme overgrazing. Approximately 72% of the vegetation is abandoned Old-Field and the 62+ weed species are uniformly distributed because of their low palatability to cattle. Two endangered species grow discontinuously in dense patches, where livestock cannot get to them--a not too

fortuitous exclusion.

The vegetation was given a low rating (Fig. 58) because of its depauperate state. Diversification may occur along the shoreline or in the shallow arms as they silt in with the implementation of the reservoir and with time. In the value function graph (Fig. 58), the low-range 0-3 variety units, the mid-range 3-7 and the high-range 7-10.

The RI's for the spatial frames (0.33 for each) were based on the opportunity for the different areas to have unusual habitats or rare species. The time RI's (0.50 for both construction and use periods) are based on the assumption that although the reservoir will create an opportunity for diversification, diversification (frame value differences) and not opportunity will change in time.

Input of data and the above considerations into the worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir of +1.1 EIU on Variety Within Vegetational Types.

Weighted Parameter

$$\begin{aligned}\text{Estimate Without} &= 1.0 ((0.33 \times 2) + (0.33 \times 2) + (0.33 \times 2)) \\ \text{Project} &= 2.0\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.50 ((0.33 \times 2) + (0.33 \times 3) + (0.33 \times 3)) \\ \text{Project-Construction} &= 1.32\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.50 ((0.33 \times 2) + (0.33 \times 6) + (0.33 \times 4)) \\ \text{Project-Use} &= 1.98\end{aligned}$$

Total weighted parameter estimate with project = 3.3

For this parameter the EQ determined from Fig. 58 is:

$$\text{"Without" EQ} = 0.26$$

$$\text{"With" EQ} = 0.32$$

Therefore, the environmental impact on Variety Within Vegetational Types is:

$$\begin{aligned}
 EIU &= (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}}) \\
 &= (5 \times 0.32) - (5 \times 0.26) \\
 &= (1.6) - (1.3) \\
 &= +0.3
 \end{aligned}$$

Man-Made Objects

The development of the Aubrey Reservoir Project will have an impact affecting the man-made objects within the project boundary and surrounding area. The present objects within the project boundary will be removed and will give the Corps of Engineers the opportunity to develop man-made objects that are limited in number and harmonious with the natural landscape. This can improve the total environmental quality of the area. Outside of the project boundary and adjacent to it the environmental quality will probably decrease.

Man-Made Objects

Man-made objects are a part of man's cultural environment. The man-made objects within the Aubrey Reservoir Project area include such features as buildings, roads, railroads, bridges, fences, electric lines, telephone lines, pipelines, farm ponds and reservoirs, construction and mining scars, and oil well pumps and storage tanks. Also included are solid waste objects such as cans, discarded washing machines, stoves, refrigerators, and automobiles and parts that have been disposed of, especially along the roads at stream crossings.

Buildings include all houses and storage structures. There are no clusters as in a hamlet, village, town, or housing development. They are of a moderate rural density. Most are single storied, but a few are two storied; therefore, they have a low silhouette or profile. Approximately 75% are of wood construction and painted, while 17% are brick, 7% stone, and 3% with asbestos siding. Most barns and other storage buildings of farms are of weathered wood with metal roofs. Even though a majority are of low silhouette, other aspects of the buildings--the design and landscaping--do not tie them into the natural setting. Structures more fitting to the area would be native

stone, which would give the appearance of softer edges and less ridged contour, and stained woods which would be softer and have a warmer feeling. The buildings or farmsteads are scattered, creating irregular, pleasing patterns of buildings. Conditions of the farmstead buildings vary from good to poor. There are no monumental buildings in the area. Yet, buildings are the most conspicuous aspect of the cultural landscape. Most of the fences are steel wire, with very few wood fences and no stone fences.

Roads are of moderate density with irregular patterns of spacing. They are not in long straight lines, but change direction frequently, winding across the landscape. The roads are narrow, occupying only a small portion of the total area. Most are covered with earth materials of sand and gravel from the local area and therefore blend into the mineral soils and rock materials of their natural environment. In the reservoir area are approximately 11 miles of farm-to-market roads which are hard surfaced. These are not as harmonious to the natural setting.

Older bridges are constructed of concrete pillars supporting wood and steel. There are narrow, unpainted, rough plank floors. Many are picturesque in their setting across narrow stream channels with crowns of trees extending over them.

Numerous farm ponds and two reservoirs are located within the proposed reservoir site. These have earthen dams covered with grass vegetation, creating a pleasing part of the landscape.

No major transmission lines cross the area with their massive lines and supports of long straight lines on the skyline and large areas of forests cut away. Instead, they are low, with few wires, supported by small wood poles. This type is not so noticeable and distracting from the landscape. Other utilities such as pipelines are underground.

Solid waste and man-made objects are represented by abandoned buildings scattered throughout the area. Some 21 abandoned houses were counted, and there appear to be several abandoned storage buildings in the project area. Drainways along the roads and especially along streams at road crossings are used as dumping grounds for cans, discarded furniture, stoves, washing machines, and refrigerators. To this can be added some unkept house sites and farmsteads and deteriorated fences. One wonders if the abandoned buildings, many of them falling down, the deteriorating fences, cemeteries being allowed to return to old-field types of vegetation, and the once-cleared

and cultivated fields becoming oldfields are signs of man allowing portions of the area to eventually return to natural settings.

Mining scars remaining from mining sand and gravel are visible in the site area. The overburden has been left in piles instead of being smoothed out so the land might be used again.

In order to make a judgment of the esthetic quality of man-made objects, visual data were obtained by field studies, and ideas were gained from Tom P. Miller and Isabel Mount Miller, architects and owners of the firm of Mount-Miller Architects, Denton, Texas.

The esthetic quality of the man-made objects depends on their degree of consonance with the natural environment. This is determined to a large degree by their density, location and patterns of distribution, size, design, color, and texture. The study then becomes concerned with structures being harmonious or subordinate to the natural and biological environment.

The region under consideration is associated with the physiographic provinces of the Eastern Cross Timbers and the Grand Prairie. With the Cross Timber is associated a bedrock of sandstone and a natural vegetation of forest, although much of the wooded area has been destroyed and now covered with crops or allowed to become old fields. The western part of the area is in the Grand Prairie which has a limestone bedrock covered with a natural vegetation of grasses, except along the streams where it is wooded. The entire area is plains, varying from smooth to slightly rolling.

Patterns of the natural landscape are irregular. This is a region of flat to low hills with gentle slopes covered with crops, grasses, weeds, shrubs, and low trees. Man-made structures must be considered in relation to the topography and vegetation of the area. Even though the structures may be functional, a design of a time period, picturesque and pleasing to an individual does not mean that they are in harmony with the natural landscape and can be given a high value rating.

The function graph for Man-Made Objects (Fig. 59) is designed to determine the environmental quality (EQ) of this aspect of man's culture by considering the quality of construction and design of structure in consonance with nature and also the density of structures. On the graph the EQ axis is assigned a value ranging from 0 to 1.0. The structure density axis has broad divisions of high density, moderate density, and sparse to no density. To the density axis has been assigned values of

no density. To the density axis has been assigned values of 0 to 6. The three diagonal lines, poor, fair, and good or no structures, express the quality of construction and design in consonance with nature.

In evaluating the man-made objects impact created by the project, the study must consider both spatial and temporal aspects of the proposed development. Spatial patterns include the project site, upstream and downstream sectors, while the temporal aspect must be evaluated as to existing construction and use conditions of the project. Each spatial sector is given a weight to indicate its relative importance within that sector. The reservoir sector is assigned $RI = 0.8$ because of the direct impact on man-made objects. The upstream and downstream sectors are assigned equal importance of 0.1 each. As to the time pattern, the existing (without the project) is given $RI = 1.0$ and with the project (construction and use) is given an $RL = 1.0$. The $RI = 1.0$ with the project is weighted between construction and use. $RI = 0.25$ has been assigned to the construction period since this is a short-term impact, and 0.75 is assigned to the use period, a long-term impact.

Ratings of Sectors Within Function Graph: Without the project man-made objects in the upstream and downstream sectors are similar (as those described in the description of parameter section for the reservoir site sector). Based on density a value of 3 is assigned and the quality of construction and design of man-made structures is judged to be fair. In this parameter most of the impact will be at the reservoir site, but the upstream and downstream are included because those living presently in the reservoir will be relocated. Many of them will move man-made objects with them either upstream or downstream, thereby increasing the density slightly. Also, as has been indicated in other sections, the reservoir may have some housing impact on the upstream and downstream sectors.

With construction of the reservoir, all presently existing man-made objects will be removed or covered with water. There will be added objects such as the dam, probably new roads, power lines, and a few buildings needed in the overall operation and function of the project. In the reservoir site density will decrease to sparse which is assigned a value of 5. With proper planning of design and construction the structures should be in consonance with nature, so a rating of good can be designated. If good planning is continued, the use period of the project should receive a high rating. Again a value of 5 is assigned for density and good for design and construction. If the design

and construction is not in consonance with nature, a lower value would have to be given for the reservoir site area. Values of 3 for a moderate density are estimated for the upstream and downstream sectors. The quality of design and construction remains fair.

The high rating for "with" is based on the assumption that the Army Corps of Engineers will follow our recommendations below. The dam hinges on the hill slopes in the Eastern Cross Timbers and extends westward across the Elm Fork Trinity River flood plains on to the Grand Prairie. If the east-west axis is designed to be a gentle curve (instead of straight lines) and with the south or leeward side having an undulating slope, then relief and configuration characteristics can be made to resemble the natural topography of the area.

Vegetation patterns on the top and along the south slope of the dam should duplicate those of the existing patterns in the area. Grasses should be planted to cover the south slope and crest of the dam. These plantings would be in harmony with those of the Grand Prairie. Along the foot of the eastern portion of the dam trees should be planted in patterns of fingers or irregular boundaries extending westward from the present wooded areas, thereby recreating topographic and vegetative patterns that resemble the present landscape. A limestone rip-rap on the water side of the dam will resemble the limestone bedrock of the Grand Prairie.

Construction scars should occur in the reservoir sector; that is, to the north of the dam. This way all scars will be covered by water.

If at all possible, buildings should be located in wooded areas. This creates less disruption to the view. If buildings are located on or near tops of hills, one does not see the tops of buildings, but the profile. If they must be placed in low areas adjacent to hills, locate in wooded areas where the crowns of trees seclude the tops of buildings. Buildings of native stone have softer edges and less ridged contour than concrete and brick structures. Buildings of stained wood are softer in appearance and would be in consonance with the environment.

Bridges spanning arms of the reservoir should be designed to be in harmony with the natural setting. Transmission lines should be kept to a minimum, their silhouettes off the skyline and where possible concealed by the vegetation.

Input of these considerations into the worksheet-matrix and calculations yielded a total impact index of the Aubrey Reservoir Project of +5.1 EIU on the Man-Made Objects.

Weighted Parameter

$$\begin{aligned}\text{Measurement Without} &= 1.0 ((0.1 \times 3) + (0.8 \times 3) + (0.1 \times 3)) \\ \text{Project} &= 3.0\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.25 ((0.1 \times 3) + (0.8 \times 5) + (0.1 \times 3)) \\ \text{Project-Construction} &= 1.15\end{aligned}$$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.75 ((0.1 \times 3) + (0.8 \times 5) + (0.1 \times 3)) \\ \text{Project-Use} &= 3.45\end{aligned}$$

Total weighted estimate with project = 4.60.

For this parameter the EQ determined from Fig. 59 is:

$$\begin{aligned}\text{"Without" EQ} &= 0.39 \\ \text{"With" EQ} &= 0.90\end{aligned}$$

Therefore, the environmental impact on Man-Made Objects is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.9) - (10 \times 0.39) \\ &= (9.0) - (3.9) \\ &= +5.1\end{aligned}$$

For this parameter, as for the Life Patterns parameters, there is that area outside of the project boundary but adjacent to the project boundary that is not but should be considered. With the project use this adjacent area will have a high build-up of man-made objects which will not be designed in harmony with the natural setting. If this area were included, the negative impact on the environment would be higher.

The impact in the area adjacent to the project boundary and extending horizontally 0.5 mile from the boundary will be a result of the reservoir. Although the Corps of Engineers can control the area within the project boundary, there is no

control of density and design of structure just outside the boundary. Within this uncontrolled area many buildings will probably be constructed. In determining the environmental impact unit based on considering the reservoir site and the 1.5 area from the boundary as the site sector, the following environmental impact unit is calculated. This calculation is based on assigning a value of 2 for density of structures and fair for design and construction.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0.1 \times 3) + (0.8 \times 3) + (0.1 \times 3)) \\ \text{Project} &= 3.0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.25 ((0.1 \times 3) + (0.8 \times 5) + (0.1 \times 3)) \\ \text{Project-Construction} &= 1.15 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Measurement With} &= 0.75 ((0.1 \times 3) + (0.8 \times 2) + (0.1 \times 3)) \\ \text{Project-Use} &= 1.65 \end{aligned}$$

Total weighted estimate with project = 2.80

For this parameter the EQ determined from Fig. 59 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.39 \\ \text{"With" EQ} &= 0.36 \end{aligned}$$

Therefore, the environmental impact on Man-Made Objects is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (10 \times 0.36) - (10 \times 0.39) \\ &= (3.60) - (3.90) \\ &= -0.30 \end{aligned}$$

It is our opinion that the latter impact index should be used in determining the total impact of the Aubrey Reservoir Project.

Composition

Composition of an area refers to the overall esthetic "picture" and concerns rare physical and biological attributes unique to the "picture."

Composite Effect

The Battelle EES expresses the importance of this parameter in terms of the interplay of land, air, water, biota and man-made objects as a visual experience that may be displeasing or spectacular. Therefore, the essence of composition is the spectacularity of a piece of nature. Ultimate evaluation depends upon how spectacular a site is and to what degree the framework is changed by the project.

The framework of the landscape of an area, like that of the human body or that of a building, is discrete; sometimes, indeed, it makes one forget its existence, but it cannot be absent, for it is what gives a work of art those "principal lines" of which Delacroix speaks in his Journal, whether it is Renoir's "At the Boating Luncheon" or the project site vista from Fairview school of yellow and translucent amber fields stretching stair step fashion to the south, down to a grey-green fringe forest that marks the meandering course of Elm Fork.

What is the essence of composition? Is it a matter of instinct or flair? Was there a subtle and secret mathematical science lurking beneath the apparent spontaneity of the masters? There are a few tricks, to be sure, in translating three-dimensional forms to a flat surface. The evaluator of this esthetics parameter interprets a scene as a plane surface surrounded by a frame and organizes the elements in relation to it. This is a rather imperious approach, tending to a restricted discipline of space conquest within the frame (pleasing proportion, center of interest, horizon, perspective), of color translation and the forever difficult conquest of light values. A perhaps freer discipline and one of difficult qualification is that of the relationships of equilibria as praised by Plato in Timaeus.

Observations for this parameter were made at numerous sites in the western, central and eastern sectors of the reservoir site. It is simple to "frame" bits of the Isle du

Bois and the Elm Fork landscape, as one transects these areas. The abandoned farm sites of the 19th century are unusual. As objects of hay storage, they have become ephemeral elements of the Cross Timbers. Their place in the landscape rivals the "composition" of the back road farms of rural Dutch Pennsylvania, yet soon they will be gone. A few will remain after the project is implemented and combined with the reflection of water; their place in the overall framework of the landscape will be possibly enhanced.

Parameter values, (low, medium or high) shown in Fig. 60 were given numerical values of 1 - 10.

Spatial RI's were estimated on the basis of the greater opportunity for a more pleasing or at least a more diverse composition with the addition of a reflecting pool over the present site and those areas above and below. Time RI's were based on the opinion that little change in the basic framework of the site would occur as the reservoir ages.

Input of the data and considerations into the worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of +0.6 EIU on unique composition.

Weighted Parameter

$$\begin{aligned} \text{Measurement Without} &= 1.0 ((0.25 \times 3) + (0.50 \times 3) + (0.25 \times 3)) \\ \text{Project} &= 3.0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.50 ((0.25 \times 3) + (0.50 \times 5) + (0.25 \times 3)) \\ \text{Project-Construction} &= 2.0 \end{aligned}$$

Weighted Parameter

$$\begin{aligned} \text{Estimate With} &= 0.50 ((0.25 \times 3) + (0.50 \times 6) + (0.25 \times 3)) \\ \text{Project-Use} &= 2.25 \end{aligned}$$

Total weighted estimate with project = 4.25.

For this parameter the EQ determined from Fig. 60 is:

"Without" EQ = 0.40

"With" EQ = 0.44

Therefore, the environmental impact on Composite Effect is:

$$\begin{aligned}
 EIU &= (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}}) \\
 &= (15 \times 0.44) - (15 \times 0.4) \\
 &= (6.6) - (6.0) \\
 &= +0.6
 \end{aligned}$$

Unique Composition

This parameter could be designated, "rare and endangered areas" since the Battelle definition of composition, as set forth in the preceeding parameter, is the degree of spectacularity of an area. Some elements of the overall pattern may be unique or so vulnerable that a project would do them irreparable harm. The key consideration, here, is degree of vulnerability of unique elements if they exist and importance revolves around the fact that their alteration is an irretrievable loss to all mankind. Clear-cutting the coastal redwoods to build a highway system or diverting the water for irrigation that plunge over Yosemite Falls are examples of such unique (rare) elements whose loss would be intolerable.

The project site was searched for rare elements as endemic composition when compared to the whole of the Elm Fork system. None were found ($EQ = 0$). In such an eventuality, the Battelle guide lines are explicit, the value function graph (Fig. 61) is not to be entered and the parameter not to be evaluated. Therefore, the Aubrey Reservoir Project will have no impact on this parameter ($EIU = 0$).

Human Interest

This category contains five components and 19 parameters. These were selected by Battelle-Columbus for the EES because they capture the potential effects of a water resource project on the educational, historical and cultural interests of people. Recent trends in education, and increased affluency, leisure time and urbanization suggest there will be an increased demand for areas which have educational, historical and cultural significance. It is important to preserve as many of these areas as possible. Therefore, the impact of water resource projects on these environmental attributes should be considered carefully during the planning and construction of reservoirs.

Educational-Scientific Packages

Parameters of this component focus attention on sites or objects which have educational and scientific value. Emphasis is placed on those sites and objects which are unusual and/or have archaeological, ecological, geological or hydrological interests to people.

The "package concept" is one which considers all the objects or sites concerned with archaeology, ecology, geology or hydrology as a single unit to be evaluated with and without the project; each object or site is not considered separately.

The following procedure taken from the Battelle-Columbus Report (1) was used:

"The procedure of identifying parameters that are relevant to a particular project evaluation involves the following steps for each individual parameter:

1. Identify all occurrences within the project area that apply to this parameter.
2. Think of all the occurrences totally as a package.
3. Determine whether or not this total 'package' is of any significance.

4. a) If it is determined that the package does have significance, refer to the value function to make a 'with-without' evaluation of the package.
- b) If it is determined that the package does not have significance, it will not be included in the evaluation.

In steps 3) and 4), the word 'significance' is of utmost importance to the evaluation procedure and the proper use of the value function. Battelle-Columbus uses two more concepts to clarify the meaning of significance. These are the terms 'internal' and 'external'. These terms help to identify the people to whom the package has significance. "Internal" refers to people who have been identified in the proposed project plan as being somehow affected by the proposed project-either beneficially or adversely-in one or more of its sectors. Thus, a package of 'internal significance' refers to a package of occurrences of archaeological (or geological, ecological, or hydrological) interest to those people who are identified by the Bureau of Reclamation as being directly affected by the proposed project. 'External' refers to all other people outside of the project area who may have an interest in the effects or impacts caused by the proposed project. These two terms do not necessarily have a particular geographical connotation or boundary, although in some projects they may.

Therefore, before the value function can be used, the question must be asked, 'Do the occurrences identified as being a part of this package have significance only to people in the project area, or do they have significance to people outside of the project area?' If the answer to the first part of the question is yes, then the package is an 'internal package' and the appropriate value function is applied. If the second part of the question is answered by yes, the package is considered an 'external package' and the appropriate function should be used. If the package has aspects of both internal and external significance, it should be considered an 'external package'."

Archaeological

The Archaeological Package includes anything which demonstrates or indicates mainly the prehistoric past in the human life and cultural activities of a people. Pre-historic is defined as "of times antedating written history". Examples include prehistoric villages, dwellings, and objects used in everyday life activities, and remains of plants or bones of animals which may have become petrified. But since actual settlement of the proposed project area did not begin until the 1840's (30), and the literature does not record any specific contacts between the Spanish or the French and the Indians within the project area, any sites having to do with Indians have been included in the archaeological parameter. Any sites, objects or structures associated with the Indians of the area deserve to be placed in the Educational-Scientific Package under the Archaeological Parameter because they mainly would be useful in teaching us something about the cultural life and activities of the Indians, even though this element is more rightly called ethnohistory than archaeology. Since no meaningful archaeological field data were obtained in this study because of severe time limitations (3 months), we have attached a "Major Red Flag" to this parameter indicating further consideration is necessary according to the EES. Without data from a professional intensive and extensive archaeological field survey, it is impossible to accurately assign "with" and "without" values to this parameter. However, by extrapolating archaeological data in a recent report on Trinity River area resources to the Army Corps of Engineers (31) to the Aubrey Reservoir site, we estimated a value significance for the Aubrey Reservoir site so a "with" and "without" evaluation could be used in the Battelle EES. Although this is only a gross estimate, it enabled use of the EES to point out at least a minimal impact.

Since the Archaeological Package may have elements of both internal and external value, it was considered as an external package in the EES. A low value significance or EQ = 0.6 (Fig. 63) was assigned to this parameter without the project for the following reasons: 1) little yet

is known of the Paleo-Indian (9500-5500 B.C.) and Archaic (5500 B.C. - A.D. 800) periods. More discoveries in the Neo-American (A.D. 800-1600) and Historic (A.D. 1600-1800) would also be useful in learning about the lives and customs of these peoples who inhabited the north central Texas area, (see Suhm, Kreiger and Jelks, 32, for discussion of these four stages of Texas archaeology); 2) since so little is known of the earlier time periods any find would have considerable value (31); 3) several archaeological sites are known in the area downstream from the proposed project and it can be assumed there will be some in the area of the proposed Aubrey Reservoir. Only one site, a Neo-American one, is known at present within the affected area (see Sciscenti, 31, for map showing all the recorded sites and note the controversial archaic site known as the Lewisville site, which is not far from the proposed project site); 4) on the basis of work done on the Brazos River (31) there is reason to believe occupation in this Paleo-Indian and Archaic area did occur and evidence can be expected to have been buried in the "river terraces and floodplain" (31); 5) "the majority of recorded sites occur at the edge of the Trinity River floodplain or on low rises located within the river floodplain. Many unreported sites may occur under the river silt where they have been buried by repeated overbank flooding" (31). The proposed project would, of course, inundate several such areas; 6) the parameter is assigned a low ($EQ = 0.6$) value significance rather than a higher one, because many parts of the Elm Fork of the Trinity will not be inundated, so that it would be possible even with the project to obtain archaeological information about the earlier periods. It must be reiterated, however, that until an in depth field survey is made we will not know whether or not a site of unique importance would be lost as a result of the Aubrey Reservoir project; and 7) although cultivation and gravel excavation may have destroyed some sites, they would be mostly of the later period and earlier finds would have greater significance.

A low value significance or $EQ = 0.6$ (Fig. 63) was assigned to this parameter during construction because if an archaeological field study is funded and completed and archaeological salvage work that is necessary is rapidly

carried out during this period, something of value may be obtained; and sites would not be inundated and lost until the reservoir fills.

A value significance of none was assigned this parameter with the project during period of use for the following reasons: 1) if salvage work is carried out intensively during construction much of the archaeology of the site will have been saved; 2) much of the area will have been inundated and no further work can be done; and 3) some work may be done in the area between conservation level and flood stage level, but it would be very difficult and would not be worthwhile unless something of great value were indicated.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir project of -4.68 on the Archaeological parameter of the Educational-Scientific Package. In the calculations below all relative importance was assigned to the site because the other spatial elements would not be affected by the project. Since the parameter was measured only qualitatively, the "weighted" EQ's were used instead of actual parameter measurements.

$$\begin{array}{ll} \text{Weighted EQ} & \\ \text{Without} & = 1.0((0 \times 0) + (1 \times 0.6) + (0 \times 0)) \\ \text{Project} & = 0.6 \end{array}$$

$$\begin{array}{ll} \text{Weighted EQ} & \\ \text{Estimate With} & = 0.4((0 \times 0) + (1 \times 0.6) + (0 \times 0)) \\ \text{Project-Construction} & = 0.24 \end{array}$$

$$\begin{array}{ll} \text{Weighted EQ} & \\ \text{Estimate With} & = 0.6((0 \times 0) + (1 \times 0) + (0 \times 0)) \\ \text{Project-Use} & = 0 \end{array}$$

Total weighted parameter EQ with project = 0.24.

For this parameter the EQ measured in Fig. 63 is:

$$\begin{array}{ll} \text{"Without" EQ} & = 0.60 \\ \text{"With" EQ} & = 0.24 \end{array}$$

Therefore, the environmental impact on the Archaeological Package is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (13 \times 0.24) - (13 \times 0.6) \\ &= (3.12) - (7.80) \\ &= -4.68 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.24 - 0.60}{0.60} \times 100 \\ &= -60\% \quad \text{which is a "Major Red Flag"}. \end{aligned}$$

A "Major Red Flag" is attached to this parameter for the following reasons: 1) the 60% negative change in EQ indicated here; and 2) the fact that the estimate was based entirely on data extrapolated from a survey of the literature rather than an adequate field study. This "Major Red Flag" indicates further consideration of the parameter.

Ecological Package

The Educational-Ecological Package marshals together all aspects of the project site that give it value as a study area for special research or instruction. Rare habitats or unusual trophic or endemic relationships may mark the area. Such assessments are made and compared with those of the areas around the project site and with the value of the project if implemented.

Importance of this parameter is self-evident. The high interest of concerned individuals in ecological processes and instruction mandates that adequate field facilities be provided and natural situations be saved. If we are to maintain a quality environment, we need to study ecological problems mankind has created, as well as natural systems, and to educate the young to weigh their every activity in terms of vanishing waters, life-giving vegetation, soil and wildlife. Only through education of our youth can we preserve the environment of tomorrow.

Plant and animal ecology classes, graduate students and professors from North Texas State University have searched the area around Denton for ecosystems that can be used for instruction and research purposes over the years. Those selected were for some structural, successional biotic insight. Areas in the proposed reservoir site have been passed up for these purposes because there are superior communities along Elm Fork south of the site and better post oak communities north of the site. Close reconnaissance during this study revealed that the present educational value of the ecology of the proposed reservoir site is quite low. Its biotic communities are extremely disturbed and consequently valuable only to study effects of overgrazing and agriculture. The present value significance is low ($EQ = 0.6$).

Educational research opportunity will increase with the reservoir. The educational-scientific possibilities are infinite and opportune as all disciplines can be present at the birth of the impoundment and follow its development. It would be particularly valuable if areas in and bordering on the reservoir were made available to ecologists for long range studies. The ecology program at the largest nearby institution, North Texas State University, would be greatly strengthened by receipt of lands adjacent to and islands in the reservoir for establishment of study sites and a research-teaching station. We strongly recommend that consideration be given to donating areas to North Texas

State University for permanent educational and research purposes. Also, with respect to education, esthetics and human interest, a large tract should be set aside as a wildlife refuge.

Since the educational value of the site will be mainly administered through universities, whose students come from throughout the world, the evaluation of this parameter was given external significance and evaluated as such.

The Battelle value scale of None, Low, Low-Medium, High-Medium, High (Fig. 63) was translated to these numerical equivalents respectively, 0-2, 2-4, 4-6, 6-8, and 8-10. RI values were assigned to construction and use time frames on an opportunity only basis, namely opportunity occurs with implementation and does not change in 20 years. Since the value of the site with the reservoir is so high, the site is given an RI = 1.0 and the depauperate upstream and downstream areas RI's = 0.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact index for the Aubrey Reservoir Project of +2.6 EIU on the Ecological Package.

Weighted Parameter

$$\begin{array}{lcl} \text{Measurement Without} & = & 1.0((0 \times 3) + (1 \times 3) + (0 \times 3)) \\ \text{Project} & & = 3.0 \end{array}$$

Weighted Parameter

$$\begin{array}{lcl} \text{Estimate With Project} & = & 0.50((0 \times 3) + (1 \times 6) + (0 \times 4)) \\ \text{Construction Period} & & = 3.0 \end{array}$$

Weighted Parameter

$$\begin{array}{lcl} \text{Estimate With Project} & = & 0.50((0 \times 3) + (1 \times 8) + (0 \times 5)) \\ \text{Use Period} & & = 4.0 \end{array}$$

Total weighted parameter estimate with project = 7.0.

For this parameter the EQ determined from Fig. 63 is:

"Without" EQ = 0.60
"With" EQ = 0.80

Therefore, the environmental impact on the Ecological Package is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (13 \times 0.8) - (13 \times 0.6) \\ &= (10.4) - (7.8) \\ &= +2.6 \end{aligned}$$

This plus value represents an ecological opportunity that will be an asset to area educational institutions if the project is constructed. Obviously it would be higher if some areas around and in the reservoir are restricted and set aside for wildlife, and ecology study and research.

Geological Package

The geological package includes aspects of the environment which add significantly to the knowledge of the history of the earth and its life as recorded in rocks and rock structures, and geologic phenomena which serve to illustrate unusual geologic processes.

The proposed Aubrey Reservoir site is on the outcrop of Cretaceous materials. The structure of the rocks dips toward the southeast and leave exposures of several different formations within the proposed site. Most of the area that will be inundated is presently composed of alluvium and terraces. That portion of the lake reservoir basin adjacent to the Elm Fork is rich in paleontological invertebrate specimens. The eastern portion that is underlain by Woodbine sandstone is of limited value for fossil collection except for a few leaf fossils.

After the reservoir is filled, wave action along the shoreline can be studied by students of shoreline development. During the periods of low water the area of exposed mud flats, miniature lacustrine plains and delta formation in the regions of incoming streams into the main lake reservoir can be studied by high school and college earth science classes. The shores that are sand covered will be ideal for studies of wind erosion and deposition.

Public school systems have stressed earth sciences during the past decade at the junior high school level; and some of the larger schools (Denton Independent Schools) have added geology courses in their high schools. North Texas State University for the past 6 years has offered a summer Institute in Earth Sciences for junior high school teachers. Since the "field trip" is the best laboratory for teaching the earth sciences, establishment of the reservoir will benefit the earth science programs at local public schools, and Texas Womens and North Texas State universities.

The importance of the Educational/Scientific Packages derives from their "internal" and/or "external" significance based upon the location of the persons that will be interested and affected by the educational feature. Considering the many lakes in the north-central area of Texas, the physical features of the Aubrey Reservoir site are not unique. The formations that offer the best opportunities for the collection of fossils are widespread from the Texas-Oklahoma line to areas south of Fort Worth. Therefore, the region is not unique for fossils. Consequently, the external significance would be negligible.

The boundary for the internal package is variable as to where people will be attracted to the lake for educational purposes. Most school field trips will be limited to 25 miles from the school. This will allow time for the students to make the trip and have adequate time to do field work while on the trip. The proposed lake reservoir will have park, picnic and restroom facilities available for use. This is an important consideration in the planning of field trips. Most of the earth science teachers are schooled in the local universities and have an acquaintance with the local geology.

The upstream and downstream were not used in determining the quality of the educational-scientific quality because they are considered to be "external". Only the site is considered, and it is given an RI of 1.0. An RI of 1.0 is given the time without project. There will be considerable removal of surface materials and roads will be opened into the new lake region as during the construction period and visitations by educational groups will increase. The value of $RI = 0.25$ was assigned to the construction period. The greatest importance of the area will occur during the use period as the full development of park and recreational facility as well as shoreline development will have taken place. An $RI = 0.75$ was assigned to this period.

The value assigned to the value significance for the without project, based upon availability and exposure was of Low-Medium and 5 for the numerical value (Fig. 62). The construction with project would be accompanied by more exposures and an easier access as the new roads are being built into the project region. The value significance would increase to the High-Medium class with 7 given as the numerical value (Fig. 62). The greatest development would occur during the use period when full development of the area would permit easier access.

Input of these considerations into a worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project to +4.4 on the Geology, Educational/Scientific Package index.

Weighted Parameter

$$\begin{array}{l} \text{Measurement Without} \\ \text{Project} \end{array} = 1.0((0 \times 0) + (1.0 \times 5) + (0 \times 0)) \\ = 5.0$$

Weighted Parameter

$$\begin{array}{l} \text{Estimate With Project} \\ \text{Construction Period} \end{array} = 0.25((0 \times 0) + (1.0 \times 7) + (0 \times 0)) \\ = 1.75$$

Weighted Parameter

$$\begin{array}{l} \text{Estimate With Project} \\ \text{Use Period} \end{array} = 0.75((0 \times 0) + (1.0 \times 7) + (0 \times 0)) \\ = 5.25$$

Total Weighted estimate with project = 7.00.

For this parameter the EQ determined by Fig. 62 is:

"Without" EQ = 0.20

"With" EQ = 0.60

Therefore, the environmental impact on the Geological Package is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.6) - (11 \times 0.2) \\ &= (6.6) - (2.2) \\ &= +4.4 \end{aligned}$$

Hydrological Package

The Hydrological Package is a parameter of the Educational-Scientific component of the EES. This package includes such unique or unusual water phenomenon as geysers, hot springs, waterfalls, and lakes of unusual properties. However, these types of water phenomena are totally absent in this area.

The occurrences in this package are considered to have substantial significance to the people living within and near the project area. Battelle-Columbus makes it clear that the terms "External" and "Internal" do not necessarily have a geographical connotation or boundary, but in some projects they may have definition. In this study, we define the internal significance as an area inclusive of a 20 mile radius of the project. Such a definition is made in order to establish and assign RI's.

The internal significance is based on the assumption that people in the immediate area are interested and concerned primarily because of their homes and land, therefore, the internal package is of utmost importance to them. There is also some rather low level interest in the educational and scientific aspects of the area. This is an ideal area for field studies for some phases of the biological sciences. Overall, there are significant interests in the "internal" occurrences presently.

The Trinity River Basin in this area, like most other water supply areas, is receiving the attention of special agencies such as the Texas Water Development Board, the Texas Water Quality Board, and the Environmental Agency. Also, the city of Dallas, as well as other cities in the Trinity River Basin, will be somewhat apprehensive as to the effects the project will have on their water supplies and quality. These people, outside of the project area, will be affected directly by the project. Therefore, the "External" Package is of some significance, although not so much as the "internal" significance.

Since the hydrological package has aspects of both internal and external significance, it is considered as an "External" Package which allows for a higher significance value. The quality descriptor "Low-Medium" is given the Hydrological Package presently. This value, according to Fig. 63, gives an $EQ = 0.7$ for the without the project.

The RI values are assigned as follows: upstream 0.10, site 0.80, and the downstream 0.10. The distribution is such because the immediate area to be inundated generates the most interest as a result of land sale, loss of homestead, and the ecological effects of inundation. Neither the upstream or downstream areas will be adversely or beneficially affected. The interests and the objections of persons upstream and downstream probably will be inconsequential.

The construction period of the project will be of interest to engineers and biologists as well as other interested groups and persons. Many characteristic patterns affording hydrological and water quality will be followed in the reservoir, however, the possibility does exist that certain modifications not predicted in the systems analysis can occur. For example, the turbidity of the water could be such that productivity would be grossly affected, and the water might not be palatable for some unpredictable reason. In such an extreme case, long range water consumption plans would be inadvertently interrupted. So, in such a case, both the internal and external significance would receive consideration.

It is predicted, because of trends at Garza-Little Elm and other area reservoirs, that interests will increase and become more significant during the use period. Therefore, using the value function graph in Fig. 63, the

"External Package" is given a quality descriptor value of "High-Medium" which results in the assignment of an EQ = 0.8 for the use period. An RI = 0.25 is given the construction period and a value of 0.75 is given the use period.

Input of these data and considerations into a worksheet-matrix and calculations below yielded a total impact of the Aubrey Reservoir Project of +2.2 EIU on the Hydrological Package.

Weighted Parameter
 Measurement Without Project = $1.0((0.1 \times 6) + (0.8 \times 6) + (0.1 \times 6)) = 6.0$

Weighted Parameter
 Estimate With Project Construction Period = $0.25((0.1 \times 8) + (0.8 \times 8) + (0.1 \times 8)) = 2.0$

Weighted Parameter
 Estimate With Project Use Period = $0.75((0.1 \times 8) + (0.8 \times 8) + (0.1 \times 8)) = 6.0$

Total weighted estimate of EQ with project = 8.0.
 For this parameter the EQ measured in Fig. 63 is:

"Without" EQ = 0.7
 "With" EQ = 0.8

Therefore, the environmental impact on the Hydrological Package is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.8) - (11 \times 0.6) \\ &= (8.8) - (6.6) \\ &= +2.2 \end{aligned}$$

Historical Packages

This component of the EES is designed to assess the impact of environmental projects on the historical sites, objects and structures in the project area. While they are not among the necessities of life, historical elements affect the emotional lives of people. The public has perhaps become reconciled to the fact that economic progress may result in historical losses; and more and more people have become concerned about minimizing this impact and in making efforts to preserve and mark sites, structures, and objects of historical interest.

Four steps were used to assess the impact of the Aubrey Reservoir Project on the historical elements. First, the historical package was divided into five parameters: 1) Related to Architecture and Styles; 2) Related to Events; 3) Related to Persons; 4) Related to Religions and Cultures; and 5) Related to the "Western Frontier". The importance of each of these to the historical package is explained further when each is considered separately.

Second, a "package concept" was adopted for each parameter. This means that each and every historical event is not considered individually and given a with-without project evaluation, but that all of them in the area affected are thought of as a whole-within each parameter-and evaluated as a package.

Third, in determining the historical significance and the impact on each parameter, an internal and an external view was taken. External significance refers to events, sites, etc. that may be important in national, regional or state history, or may be of sufficient distinction or unique in some way so as to obtain wider than local interest. As indicated below, if something is considered to have external significance it is given a higher value or significance since an effect upon it would affect a larger number of persons (Fig. 65).

Internal significance refers to those developments within the affected area that do not have enough importance to be of general interest to persons other than those who have some ties with or in some ways are familiar with the land to be inundated. In some cases this means the people who now live in or adjacent to the affected site, but in

many cases it refers to people who once lived there and who may occasionally visit relatives or return to engage in nostalgic reflection on their own personal past. As might be seen even the most mundane and ordinary developments may have some level of significance for such persons. Yet since they affect fewer people, such events are given a lower value rating in determining the historical impact of the project (Fig. 64).

Fifth, five "quality descriptors" were used in both the internal and external value functions: High, High-Medium, Low-Medium, Low, None. Figs. 64 and 65 show the quality descriptors and their respective EQ's for both the internal and external packages.

The general bases for determining what the quality descriptors will be, or what the value significance will be are: 1) The number of people visiting or using the components of the package; 2) The intensity of interest shown by those people making use of it; 3) The intensity of objections expressed by people if change to the package or a part of it is indicated; and 4) The value placed on the package by an expert in the field. Sufficient narrative will accompany the description of each parameter to explain the bases for assigning value significance both with and without the project. The quality descriptors will be used to assign in the case of each parameter a value significance to the site: as it exists without the project now; with the project during the construction period; and with the project during the use period.

In dealing with the parameters of the historical package, in each case all temporal elements are considered as indicated above, but there will be only one spatial element, the site and its RI will be 1.0. No importance is assigned to upstream and downstream areas.

An explanation of research methods, comments on the literature, and a general historical background of the affected site are contained in a narrative in the Archaeological-Historical-Cultural Report in the Environmental Elements section.

Architecture and Styles

Structures, sites and objects often serve as unusual examples of certain periods, styles, or methods of construction, and thus have considerable historical value. Certain structures may be significant because they are representative of the work of an important master builder, designer, or architect. In determining the significance or value of such structures, sites and objects, the following have been taken into consideration: location, design, setting, materials, workmanship, feeling and association.

A value significance of none has been assigned to the External Package of this parameter at all time periods with or without the project, for the following reasons: 1) there are no unique structures within the area of the proposed project; 2) of 140 structures in the affected area, only one appears possibly to have been built before 1890 and it has no special distinction; 3) 20 appear to have been built between 1890 and 1910; half of these are unoccupied and several are badly dilapidated; 4) while some of these are examples of a style of ranch-farm architecture worthy of preservation, there are several other homes in the area that will not be affected that are fully as good as examples; 5) these homes have been deteriorating at a rapid rate over the last several years; and 6) there are no state historical markers in the site area, or none planned at this time.

An Internal Package significance of Low-Medium or $EO = 0.2$ (Fig. 64) was assigned to this parameter without the project now for the following reasons: 1) the structures are of significance to relatively few people; 2) the quality of the structures has greatly deteriorated; 3) for every house now standing at least one other has burned or been razed. People are therefore accustomed to at least the natural loss of such landmarks. The sites of the homes are there, however, without the project, which is a reason for assigning it a Low-Medium significance is that people who presently live in the area, and those who may occasionally visit it who once lived there, will

be affected by the loss of homes in the proposed project site. These structures are related in their minds to the individuals and families who once lived in them. A good example can be seen in the homes built by the three Hammons brothers about the turn of the century (see Plate IV for location). Although none of the brothers is still living, almost every senior citizen who has spent his life in the northern part of Denton County or southern Cooke County knows about them. The proposed project would take two of them and leave the third.

A value significance of Low-Medium, EQ = 0.2, (Fig. 64) was assigned to this parameter with the project during the construction period for the following reasons: 1) most structures would still be standing and their historical value would not yet be destroyed; 2) if anyone wished to move them that might be done; and 3) emotional disturbance over loss of the structures would be highest during this period, but would disappear later.

A value significance of None was assigned to this parameter with the project during the use period for the following reasons: 1) none of the older homes is significant or valuable enough to be moved, and moving would destroy most of the historical integrity and nostalgic significance they have; 2) in the case of the Hammons brothers homes mentioned above, a historical marker might be placed on the remaining structure which would relate the story of all; the house would be, however, in a relatively inaccessible place once the reservoir is completed and very few people would visit it; and 3) not only would the structures be gone with inundation, but so would the sites of these and of other homes that are no longer there now.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -1.98 EIU on the Architecture and Styles Parameter of the Historical Package.

In the calculations below all RI has been assigned to the site because the other spatial elements would not be affected by the project. Since this parameter is measured qualitatively, EQ's are weighted in the following calculations instead of parameter measurements.

Weighted Parameter
 Measurement Without Project = $1.0((0 \times 0) + (1 \times 0.2) + (0 \times 0))$
 = 0.20

Weighted Parameter
 Estimate With Project = $0.1((0 \times 0) + (1 \times 0.2) + (0 \times 0))$
 Construction Period = 0.02

Weighted Parameter
 Estimate With Project = $0.9((0 \times 0) + (1 \times 0) + (0 \times 0))$
 Use Period = 0

Total weighted EQ with project = 0.02.

"Without" EQ = 0.20
 "With" EQ = 0.02

Therefore, environmental impact on Architecture and Styles is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.02) - (11 \times 0.2) \\ &= (0.22) - (2.2) \\ &= -1.98 \end{aligned}$$

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.02 - 0.20}{0.20} \times 100 \\ &= -90\% \quad \text{which is a "Major Red Flag".} \end{aligned}$$

We believe that since the present EQ for this parameter is rather low, the "Major Red Flag" exaggerates the impact of the reservoir.

Events

Certain sites, structures, and objects depict or are associated with significant events in the history of the United States. Such events might be important because of the influence they played in the pattern of development in the United States. Examples of historical elements related to events are battlefields, birthplaces, graves, sites of early communities, locations of significant discoveries.

A value significance of None (Fig. 65) has been assigned to the external package of this parameter either with or without the project at all time periods because: 1) no events, discoveries, or developments occurred within the site that are of national, state, or regional significance; 2) while events or developments occurred within the site that are of significance as local historical elements, none are especially peculiar or unique, i.e. similar developments occurred in the area that will not be affected; and 3) no state historical markers are presently placed in the area, and as far as can be discovered, none are officially or unofficially planned.

A value significance of Low-Medium or EQ = 0.2 (Fig. 64) was assigned to the Internal Package of this parameter without the project at this time because: 1) the affected area includes the site of both the Old Bloomfield community on Lick Creek in Cooke County, and the newer Bloomfield community across the creek to the east and just west of Farm Road 372 (see Plate IV). Old Bloomfield, founded in 1875 and reaching its highest development in 1882, represents the earlier intensive agricultural development of this section of the Eastern Cross Timbers, an intensive use which has not existed in the last several years (33). Nothing but foundations remain of Old Bloomfield, although the newer site still has reunions and the church is used as a community center. However, it is not the only community of this type in the area; e.g. Hemming, 4 miles west went through the same development a short time later, no longer exists, and will not be affected

by the project; 2) the affected area includes the site of another community in Denton County about a mile south of Farm Road 455 and just west of the Elm Fork (see Plate IV). Originally known as the Sullivan Community founded in 1847 (34), it went through stages known as Cozner, and perhaps other names, but in recent years was referred to as Vaughantown. It never reached the size of Bloomfield but was representative of the intensive agricultural use of the Elm Fork bottom land in the late 19th and early 20th centuries, and of a population density that has not been apparent there for several decades now. No structures remain there now and no intensity of interest revealed by visitors is apparent. Yet most of the long-time residents of northern Denton County and southern Cooke County remember it with some nostalgia, having attended church or bought groceries there. Again, the sites of other such communities exist outside the affected area, so the community has no unique distinction; 3) the affected area includes the site of the old H. C. French mineral well located on the Wayne Sitzes farm on Farm Road 372, just south of Bloomfield, (see Plate IV). It was operated as a commercial enterprise in the 1890's and early 1900's, and was representative of the belief widely held then of the general medicinal qualities of mineral water of this type. The well was visited, mostly by local people but also by people widely scattered across the region as certified to by the ubiquitous testimonials accompanying the advertising for the well. It has not been operated commercially for several decades and now has only historical interest. Although the well still exists and is used, it does not of course have the same character, or same structure around it, as in its earlier period of use. There is no intense interest in it and it does not represent a unique historical phenomenon. Tioga, a few miles northeast, had several such wells; and 4) many other events, too numerous and mundane to mention specifically, occurred within the affected site, that have significance only to people who live in the area or once lived in it and return occasionally to visit. While such events have no particular historical significance, the sites where they occurred cannot be inundated without having an emotional impact.

A value significance of Low or EQ = 0.1 (Fig. 64) was assigned to the Internal Package of this parameter with the project during construction for the following reasons: 1) historical markers can be placed at the nearest appropriate spot on the perimeter of the lake to briefly tell the story of old and new Bloomfield, and of Vaughtantown. They would be more accessible than the sites of either of the old communities, which are now on private land. Such markers would enhance the appreciation of local history by visitors to the site by giving the facts succinctly and accurately; and 2) in the first 5 years (construction period) any increase in value significance would be more than offset by the emotional impact of the inundation of the actual sites of both those specifically mentioned and those not specifically noted.

A value significance of High-Medium or EQ = 0.3 (Fig. 64) was assigned to the Internal Package of this parameter with the project during the use period because: 1) the emotional impact occasioned by inundation will have declined and be of no significance; 2) since appreciation for the events that occurred within the affected site will have declined without the project within 20 years, because fewer people will probably have emotional ties due to deaths and loss of ties with the region, the marking and preservation of the sites in the fashion recommended will have added significance; 3) the sites will still have only internal significance; and 4) a factor in the environmental quality rating in both during construction and use periods with the project is that prospective inundation will send local historians and local journalists searching for the historical facts about the affected sites so that they might be preserved for posterity in literature. Thus historical information that might be lost may well be preserved because of the project. The specific historical literature about this area is now extremely scanty.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir of +0.66 on the Events parameter of the Historical Package. In the calculations below all relative importance has been assigned to the site because the other spatial elements would not be affected by the project. Since the parameter was measured only qualitatively, the calculations below use EQ's instead of absolute parametric values.

Weighted Parameter
 Measurement Without = $1.0((0 \times 0) + (1 \times 0.2) + (0 \times 0))$
 Project = 0.20

Weighted Parameter
 Estimate With Project = $0.2((0 \times 0) + (1 \times 0.1) + (0 \times 0))$
 Construction Period = 0.02

Weighted Parameter
 Estimate With Project = $0.8((0 \times 0) + (1 \times 0.3) + (0 \times 0))$
 Use Period = 0.24

Total weighted estimate of EQ with project = 0.26.
 For this parameter the EQ determined from Fig. 64 is:

"Without" EQ = 0.20
 "With" EQ = 0.26

Therefore, the environmental impact on Events is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.26) - (11 \times 0.2) \\ &= (2.86) - (2.20) \\ &= +0.66 \end{aligned}$$

Persons

There are many persons who are considered to have been of importance in the history of the United States. This parameter includes significant sites, structures and objects associated with the lives, careers, and activities of such people.

A value significance of None was assigned to the External Package of this parameter for with or without the project at all time periods because: 1) there are no sites, structures, or objects associated with individuals of great importance in national, state or regional history. This is on the basis of the judgement of a professional historian and the fact that no intense

interest has been shown in the sites associated with the persons mentioned below in connection with internal significance; 2) no historical markers associated with prominent persons are placed in the affected site and none apparently are planned; and 3) even with markers placed as recommended below, the sites would not be visited by large numbers of people across the nation, or even across the state.

A value significance of Low or EQ = 0.1 (Fig. 6-4) has been assigned to the Internal Package of this parameter without the project at this time because: 1) the affected area includes the site of the grave of Dr. John S. Riley. Uncle of the noted poet, James Whitcomb Riley, Dr. Riley settled at Bloomfield in 1871, after serving as an officer in the Confederate Army. His medical practice, personality, and distinguished background made him widely known in the north Texas region. He died in 1915 and is buried in a well-marked grave in Jones Cemetery, which will be inundated by the Aubrey Reservoir. The site of his home for many years, will not be inundated and it is close to the reservoir site. Dr. Riley is still remembered by the older people in the area and is known of by many of those much younger who did not know him; 2) the affected area may or may not include the site of another individual whose name cannot be discovered in the literature or by other methods. The doctor for a noted French socialist community, New Icaria, which was located in southwestern Denton County (not in the affected area) was exiled and settled in the area west of Pilot Point; it is assumed that he gave the stream Isle du Bois its name (34). If it were possible to pin down the site of his residence and it were in the affected area it would give added significance to the reservoir site; and 3) the affected area includes the sites of the graves and of the residences of several early settlers in both Denton and Cooke Counties. While these individuals, e.g. John Strickland, who died in 1874, whose grave and that of his wife is located about a mile north of Farm Road 455 and just east of the Elm Fork (see Plate IV), are not especially noted as historic personages for anything other than being original white settlers, they do have some local historical significance (30). They have, for example, early land surveys named after them the Strickland survey.

A value significance of Low-Medium or $E_p = 0.2$ (Fig. 64) has been assigned to the internal package of this parameter during construction period because: 1) an improvement in appreciation of this historical element and of its value can be effected by a) moving the grave of Dr. Riley to a new spot in the general area that would not be affected and by placing a historical marker briefly detailing the historical facts of his life; perhaps his homesite should also be marked, b) moving the graves of early Denton County settlers in Davis and Strickland cemeteries (see below) to new cemeteries in which they might be put in a special section marked early county pioneers. Early Cooke County settlers in the other cemeteries that would be inundated (see below) could be done the same way. If this is done and the county commissioners agree to maintain the new cemeteries-which seems likely-then visitors to the area would much more appreciate the persons who played a part in the early history of their local area; 2) more visitors would be drawn to the sites if the above recommendations are carried out, than presently come, because the cemeteries mentioned are all poorly maintained and not easily accessible; 3) there will of course be an emotional impact when the sites associated with these persons are inundated, but assurances that these things recommended above would be should lessen the impact; and 4) an improvement in this historical element would be effected also because the publicity associated with inundating the area would cause local historians and journalists to search for and publish and thereby preserve additional historical information about the sites associated with persons in the affected area. Again the literature is very scanty at present.

A value significance of Low-Medium or $E_p = 0.2$ (Fig. 64) was assigned to the Internal Package of this parameter during the use period because: 1) the reasons given above would still apply; 2) there would be no justification for raising the value significance, because the decline in publicity given to the improvements made and living with and seeing the improvements would cause them to be less novel to the people affected; and 3) it is unlikely that these individuals are going to become any more important as historical figures.

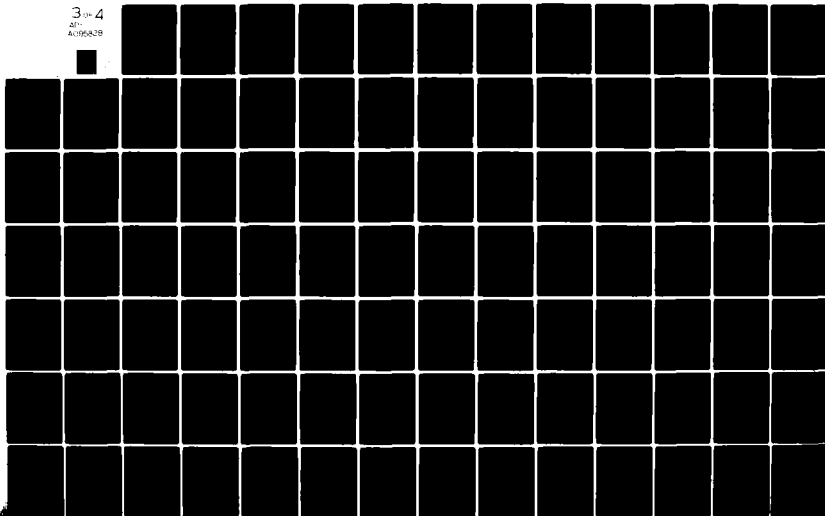
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Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of +1.1 EIU on the Persons parameter of the Historical Package.

In the calculations below all RI has been assigned to the site because the other spatial elements would not be affected by the project. Since the parameter was measured only qualitatively, the calculations below use EQ's instead of absolute parametric values.

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Measurement Without} &= 1.0((0 \times 0) + (1 \times 0.1) + (0 \times 0)) \\ \text{Project} &= 0.1 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.2((0 \times 0) + (1 \times 0.2) + (0 \times 0)) \\ \text{Project-Construction} &= 0.04 \end{aligned}$$

$$\begin{aligned} \text{Weighted Parameter} \\ \text{Estimate With} &= 0.8((0 \times 0) + (1 \times 0.2) + (0 \times 0)) \\ \text{Project-Use} &= 0.16 \end{aligned}$$

Total EQ with project = 0.2.

For this parameter the EQ determined from Fig. 14 is:

$$\begin{aligned} \text{"Without" EQ} &= 0.1 \\ \text{"With" EQ} &= 0.2 \end{aligned}$$

Therefore, the environmental impact on Persons is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.2) - (11 \times 0.1) \\ &= (2.20) - (1.10) \\ &= +1.10 \end{aligned}$$

Religions and Cultures

Sites, objects, and structures of historical significance related to religions and cultures that have been important in the past but are not used in present times as a part of the practice of a religion or culture are an important historical element. Examples are Indian burial grounds, areas of religious importance to Indian tribes of the past, church buildings, missions, cemeteries and etc.

A value significance of None has been assigned to the External Package of this parameter for with and without the project at all time periods because: 1) there are in the affected area no sites, structures, or objects associated with religious or cultural groups that have any national, state-wide or regional significance. Those that are of local significance have no unique distinction, i.e., other examples that are as good may be found in the general area that will not be affected; and 2) there are no historical markers in connection with religions and cultures placed in the affected area and there are no plans to place any.

A value significance of High-Medium or EQ = 0.3 (Fig. 64) was assigned to the Internal Package of this parameter without the project at this time because: 1) the area affected includes four cemeteries, Davis, Strickland, Jones and Bloomfield (see Plate IV). Only Bloomfield is still being used as a cemetery, but it includes graves of persons dying as early as the turn of the 20th century. All the others have only historical value, i.e., are not presently being used as burial places; 2) the affected area includes four family plots, referred to as Plots 1, 2, 3, and 4 in Plate IV. They have not been used recently and have only historical value; 3) only one of the cemeteries, Bloomfield, and none of the family plots are well tended. They are grown up in grass, briars and weeds. All of them are reasonable accessible, but only Bloomfield is well marked; 4) the cemeteries have historical integrity as they now exist, for they bring recall of the lives of these people even to one who did not know them. They have some value to the social historian; 5) the affected area includes

Bloomfield church building. No services have been held there for over a decade, and thus its only value is historical, but the building is not old or unique. It does have a hold on the emotions of those who live there and those who formerly did and occasionally visit, for it is used as a gathering place and center for groups who work in the cemetery periodically; 6) the proposed project would inundate St. James Baptist Church (see Plat IV). Services are still held there and the impact was assessed as a part of the Cultural Package in the Religious Groups parameter. The building does have some internal historical value, but it is assumed that the building will be moved; 7) the proposed project would inundate at least one, and possibly more, Indian burial sites, but these have been consigned to the Educational-Scientific Package under the parameter of Archaeology as Neo-American archaeological sites.

A value significance of None has been assigned the Internal Package of this parameter with the project during construction because: 1) inundation of the sites of the cemeteries and the churches, even after they have been moved should cause considerable emotional disturbance; people who have been ignoring grandfather's grave for years will be suddenly upset. How much they are affected will depend some on moving plans and assurances given. For recommendations see below; and 2) moving the cemeteries and the churches will destroy much, but not all (see below), of their historical integrity.

A value significance of Low-Medium or EQ = 0.2 (Fig. 64) was assigned the Internal Package of this parameter with the project during the use period for the following reasons: 1) it is assumed that the graves and markers will be moved into either well-tended present cemeteries or that new ones will be established and maintained. Financing maintenance may pose a problem, for local cemeteries are maintained by volunteer workers and contributions to local cemetery associations. If these, however, are deemed to have historical value, the county governments might be willing to assume the task; 2) while the historical integrity of the cemeteries would be adversely affected by moving them from their original sites, the impact would be least adverse by moving each one the shortest distance possible, consonant with good access, and keeping the original name, as specifically recommended below:

- a. Family plot 1 should be combined with Davis Cemetery.
- b. Family plot 2 should be combined with Strickland Cemetery.
- c. Family plots 3 and 4 should be moved to Tyson Cemetery in the area that will not be inundated.
- d. Bloomfield and Jones Cemeteries might well be moved and combined, with both names retained.
- e. Each cemetery should be marked with a state historical marker giving its history and original location.
- f. Bloomfield Church should be moved near the newly established Bloomfield Cemetery.
- g. St. James Church should be marked with a state historical marker when moved to Pilot Point (see Cultural Package);

3) if recommendations are followed there would be a considerable improvement in accessibility, convenience and emotional satisfaction to those for whom the cemeteries have emotional meaning; and 4) for historians and those who have no emotional ties with the persons buried in the cemeteries there would be less value in visiting such well-marked, well-tended cemeteries that are not in their original place, than there would be in poking about in old grown up cemeteries. But the enjoyment of the cemeteries by a larger number of people if they were well-marked and more accessible would partly offset this adverse effect.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir project of -1.54 EIU on the Religions and Cultures Parameter of the Historical Package. In the calculations below all RI is assigned to the site because the other spatial elements would not be affected by the project. Since the parameter was measured only qualitatively, the calculations below use EQ's instead of absolute parametric values.

Weighted Parameter
Measurement Without Project $= 1.0((0 \times 0) + (1 \times 0.3) + (0 \times 0))$
 $= 0.3$

Weighted Parameter
Estimate With Project-Construction $= 0.2((0 \times 0) + (1 \times 0) + (0 \times 0))$
 $= 0$

Weighted Parameter

$$\begin{aligned}\text{Estimate With} &= 0.8((0 \times 0) + (1 \times 0.2) + (0 \times 0)) \\ \text{Project-Use} &= 0.16\end{aligned}$$

Total EQ with project = 0.16.

For this parameter the EQ determined from Fig. 64 is:

$$\text{"Without" EQ} = 0.30$$

$$\text{"With" EQ} = 0.16$$

Therefore, the environmental impact on Religions and Cultures is:

$$\begin{aligned}\text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.16) - (11 \times 0.3) \\ &= (1.76) - (3.30) \\ &= -1.54\end{aligned}$$

$$\begin{aligned}\% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.16 - 0.30}{0.30} \times 100 \\ &= -46.6\% \quad \text{which is a "Major Red Flag".}\end{aligned}$$

Western Frontier

A proposed project may affect an area which is uniquely associated with the Western Frontier. This parameter may include places which are not related to a specific person, event, or religion or culture of historic significance, but may still be of importance to this era of history. Examples might be pioneer or cattle trails.

A value significance of None was assigned to both the Internal and External Package of this parameter at all time periods both with and without the project for the following

reasons: 1) there are no sites objects, or structures related to the Western Frontier that have not been associated with events, persons, architecture and styles, or religions and cultures; 2) the well-known sites in this area that are associated with the Western Frontier miss the site of the proposed Aubrey Reservoir project. For example, the site of the Old Preston Road, originally called the "Central National Road of the Republic of Texas", misses the area a few miles to the east; a well-defined cattle trail feeding into the Chisholm Trail at the Red River misses it a few miles to the west; so does the Butterfield State Route; no permanent Texas Ranger Camp was located in the affected site; there are well-defined stream crossings in the site, but they were apparently known only to the people of the area and have no particular significance; according to literature and legend, Sam Bass was not associated with any particular part of the area to be affected; no Indian battles or massacres can be found to have occurred there; and 3) a part of the "Old Wire Road" as it was called originally will be inundated. The road between Pilot Point and Sanger was called this because a telegraph line was built along it from Pilot Point to Bolivar. The road has, however, been rebuilt in slightly different places than it originally ran, and furthermore only a portion of it will be inundated. Therefore, the Aubrey Reservoir Project will have no impact (EIU = 0) on the parameter Western Frontier.

Cultures

Factors of cultural importance are defined as those places, objects, and structures that are important to the present-day activities of subcultures existing in this country. They are important and of value, not because of their educational or historical value, but because they are presently a significant part of people's lives. A disruption to these factors would result in a significant change to the cultural practices of a people.

For example, there are a large number of Indian tribes in the western United States. Some of the tribes have structures and areas of land that are particularly important to

their daily activities and religious beliefs. Such areas may not have significance to the majority of American people, but may be extremely important to a small minority of people. Because such people are a minority and they are often ill-represented, special mention must be made of situations where a proposed project may affect a people in these ways. The same type of situation may occur with other ethnic groups and religious groups.

The value function (Fig. 66) for the parameters under Cultures has three major categories of quality descriptors: 1) Existing; 2) Improved; and 3) Disruption to Existing. "Existing" refers to the present cultural practices and activities of a people. "Existing" will be assigned a value from 0.6 to 0.8 depending upon the level of complexity or development of the cultural activities. "Improved" refers to any improvement that might occur to the culture with the proposed project. This was evaluated with the aid of the group affected. "Disruption to Existing" refers to any disruption occurring to the cultural activities of a minority group as a result of the proposed project. Disruption is further defined in the value function by "High" (A), "Medium" (B), and "Low" (C). This, too, was evaluated with the assistance of the group affected.

Indians

This project must be reviewed to determine if it will either adversely or beneficially affect the cultural practice of any Indian tribe. If so, a "with-without" evaluation must be made to indicate the importance of the effects on the tribe. A value significance of None has been assigned to this parameter either with or without the project at all time periods because no Indian tribes or families live within the affected site. Therefore, the Aubrey Reservoir Project will not affect Indian parameter (EIU = 0).

Other Ethnic Groups

This project should be reviewed to determine whether it will either adversely or beneficially affect the cultural practices of any other ethnic groups (e.g., people of Mexican-American or Japanese descent, or Blacks). If it will, a "with-without" evaluation must be made to indicate the importance of the effects to the ethnic group. A value significance of None has been assigned to this parameter at all time periods either with or without the project because: 1) no people of Mexican-American, Japanese-American or any ethnic group other than two Black family living in the affected site and one other Black family living on the perimeter whose land would be affected. These families are not living in a distinct area and could not be called a group; they live among Whites; 2) a church, St. James Baptist Church, with an all Black membership, is located within the area that will be inundated and will have to be moved. No cultural effect is seen because all of the members except one family live in Pilot Point, outside of the affected area; the minister of the church lives even farther away, in McKinney. There will be, of course, an effect on the members of the St. James Church, but it is considered in the parameter of Religious Groups. Therefore, the Aubrey Reservoir Project will not affect other Ethnic Groups parameter (EIU = 0).

Religious Groups

This project should be reviewed to determine if it will either adversely or beneficially affect the activities or practices of any religious groups. If it does, a "with-without" evaluation must be made to indicate the importance of the effects to the religious group. A value function of EQ = 0.6 (Fig. 66) indicating a low level of complexity was assigned to this parameter as it exists because: 1) the

association, it is recommended that they be given special financial and leadership assistance in moving the church building to a site either in or near Pilot Point where the members live; 4) if the above recommendations are carried out the above adverse affects would be outweighed and a beneficial impact should be the result with the project because the church would be closer to the members. They would then save on transportation, and those without cars could possibly walk to church. Therefore, the church might be used more often for social affairs; and 5) the above recommendations and value judgements are made on the basis of talks with some of the members and with at least two deacons of the church. They seem to indicate that the members are not unhappy with the present location of the church, but neither would they be unhappy if the building were moved into town, i.e., if they did have to be out money or effort.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of 0 EIU on the Religious Groups parameter of the Cultures Package. In the calculations below all RI is assigned to the site because the other spatial elements would not be affected by the project. Since the parameter was measured only qualitatively, the calculations below use EQ's instead of absolute parametric values.

Weighted Parameter

Measurement Without Project = $1.0((0 \times 0) + (1 \times 0.6) + (0 \times 0))$
= 0.60

Weighted Parameter

Estimate With Project-Construction = $0.20((0 \times 0) + (1 \times 0.4) + (0 \times 0))$
= 0.08

Weighted Parameter

Estimate With Project-Use = $0.80((0 \times 0) + (1 \times 0.65) + (0 \times 0))$
= 0.52

Total weighted estimate of EQ with project = 0.60.

only religious group that would be affected by the project is the St. James Baptist Church located 2.25 miles north of Pilot Point. It is not only a religious group but the church has only Black members; 2) conversations with Deacons and church leaders reveal that no church records exist. This is a completely independent congregation with no administrative ties to a larger association; 3) the church has both few members with few attending regularly. The average attendance is about 25 or 30; and 4) all the members except one family live outside of the affected site, and this family lives over 2 miles from the church. The minister of the church lives in McKinney.

A Disruption to Existing ($EQ = 0.6$; Fig. 66) causing a decline to $EQ = 0.4$ seems indicated during construction for the following reasons: 1) the members are from a minority group accustomed to discrimination; they will expect the worst. Already rumors have them somewhat upset. There will of necessity be disruption in church services for the congregation while the church is being moved; 2) the prospect of inundation will have its greatest emotional impact during the first 5 years (construction) of the project; and 3) disruption can be made least adverse by good communication with the affected group. If patient explanations are made and assurances are given along the lines of the recommendations given below then the disruption should still be low rather than medium or high as indicated above. An improvement or beneficial input in this parameter to $EQ = 0.65$ (Fig. 66) with the project seems indicated for the following reasons: 1) there will be a temporary adverse impact because of the nostalgia affection for the church on the old site, but this should decline rapidly as adjustments are made and the members who are older die and others move. This is indicated by the fact that many of the present members of the congregation do not even know the history of the church; 2) the improvement to existing was not considered greater than from $EQ = 0.6$ to 0.65 because there would be some depreciation in the aesthetic value of the church by moving it into town. It has a beautiful and pastoral setting where it is, in a grove of trees, with no other buildings around it; 3) because the members of the congregation are of a minority and would be hampered by inexperienced leadership, low education and low economic position, and are not members of a larger

For this parameter the EQ determined from Fig. 66 is:

"Without" EQ = 0.60

"With" EQ = 0.60

Therefore, the environmental impact on Religious Groups is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (7 \times 0.60) - (7 \times 0.60) \\ &= (4.20) - (4.20) \\ &= 0 \end{aligned}$$

Mood/Atmosphere

Mood/Atmosphere parameters are those we distinguish as experiences of beauty from our previous sense-perception experiences. We cannot always be sure what is beautiful and what is not. A rusty bedsprings lying in a bed of poison ivy near the Isle du Bois west of Pilot Point seemed to one observer to have some "inner truth" as he framed it in his mind, changing values, comparing negative and positive spaces and deciding on the geometry of composition. Possibly the bedsprings evoked less feeling in the individual who hurriedly discarded it or would be of less worth to the individual who is both allergic to poison ivy and such "contaminants of the countryside" as a bedsprings half-buried in a muddy ditch.

It was not our contention to explore the metaphysics of beauty and truth as have Plato, Aristotle, Philostratus, Plotinus, Hegel and Kant, but merely to arrive at measures which fit the traditional views of the majority.

The importance of Mood/Atmosphere is highly subjective. What good is a sunset, or the remoteness of a climax forest when even the insects are still? What of the sweep of blue-bonnets up a hill country hillside or the splume of tiny waterfalls over the limestone near Lakey, Texas? Is it not sufficiently good they uplift one's spirit, lowered by the travail of urban living. Perhaps we need ever more to turn

to the countryside and the healing therapy of forests and hills and their rich company of plants as we are caught up in the demands of an increasingly industrialized society. Yet we have neglected and often destroyed these elements of mystery, awe, isolation and "oneness" with nature.

Three observational sites were chosen, one from each major section of the proposed reservoir site. These were the western bank of Elm Fork for the western arm, the eastern bank just west of Tioga for the eastern arm and Fairview ridge along the northern contour for the central portion. Observations were made late in May and at dawn, noon and dusk to average mood sensations. Downstream observations were made along Farm Road 2163 and upstream estimates were made at Prairie Grove.

Parameter measures shown in Fig. 67 were subjective averages on a scale of 10 units, low values ranged from 0-3, medium values from 3-7, and high values from 7-10. Awe-inspiration would rate a 10, for example, if the area was comparable to the awe-inspiration, after all factors of awe and inspiration were combined, of the Grand Canyon. Mood values were variable for any given observational site. At dawn, one observer noted at the Fairview ridge site, the undulating fields of Aristida and scattered Diospyros and a tumble-down Payne's Grey farmhouse framed against the skylight on a rise to the left, all became, as the light strengthened, a carot - a quietness, a mystery, a peace as only he painted it. At noon, the harsh overhead sun revealed weedy, worn-out fields of earth color more like the drab, early landscapes of Van Gogh.

At dusk, landscape integration returned to the same view and a certain quietness and mystery also returned in the clear cerulean sky as it backlighted the darkening violet-red synfolium of the forest on the ridges.

Spatial RI values were set at 0.30 for upstream, 0.30 for downstream and 0.40 for the site. Mood/Atmosphere parameters will probably not change much from what they are presently, above or below the project site, but the addition of a large reflecting lake and the moods water can take with changes in light increases the opportunity for improvement at the site.

Time RI values were set at 0.50 for construction and 0.50 for use periods. Opportunity for any change in 20

years in the overall beauty of the project area would be minor when compared to the change made by the 35,050 acre lake. However, if the areas adjacent to the reservoir are left to "return to nature" the Mood/Atmosphere quality will be enhanced during the use period.

For each parameter, in turn, input of the data and considerations into a worksheet-matrix and calculations below yielded the following impact of the Aubrey Reservoir on Mood/Atmosphere parameters:

Awe-Inspiration

Weighted Parameter

Measurement Without Project $= 1.0((0.30 \times 1) + (0.40 \times 1) + (0.30 \times 1)) = 1.0$

Weighted Parameter

Estimate With Project-Construction $= 0.50((0.30 \times 1) + (0.40 \times 3) + (0.30 \times 1)) = 0.90$

Weighted Parameter

Estimate With Project-Use $= 0.50((0.30 \times 1) + (0.40 \times 4) + (0.30 \times 1)) = 1.10$

Total estimate with project = 2.0.

For this parameter the EQ determined from Fig. 67 is:

"Without" EQ = 0.10

"With" EQ = 0.12

Therefore, the environmental impact on Awe-Inspiration is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.12) - (11 \times 0.10) \\ &= (1.32) - (1.10) \\ &= +0.22 \end{aligned}$$

Low without project measurements were based on the opinion that there is little awe in weedy fields, uniformly depauperate forests and muddy, intermittent streams.

Isolation/Solitude

Weighted Parameter
Measurement Without Project = $1.0((0.30 \times 4) + (0.40 \times 4) + (0.30 \times 4)) = 4.0$

Weighted Parameter
Estimate With Project-Construction = $0.5((0.30 \times 3) + (0.40 \times 2) + (0.30 \times 3)) = 1.3$

Weighted Parameter
Estimate With Project-Use = $0.5((0.30 \times 2) + (0.40 \times 1) + (0.30 \times 2)) = 0.8$

Total weighted estimate with project = 2.1.

For this parameter the EQ determined from Fig. 67 is:

"Without" EQ = 0.4

"With" EQ = 0.2

Therefore, the environmental impact on Isolation/Solitude is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.2) - (11 \times 0.4) \\ &= (2.2) - (4.4) \\ &= -2.2 \end{aligned}$$

Without the project measurements of 4 were compared to wilderness areas as 10, isolated from even overhead aircraft flight. The areas seems remote although it is of easy access because of a maze of back-roads. With the project and in time the area will attract many people from the megatropolis to the south and isolation will drop in quality.

$$\begin{aligned} \% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\ &= \frac{0.2 - 0.4}{0.4} \times 100 \\ &= -50\% \quad \text{which is a "Major Red Flag".} \end{aligned}$$

Mystery

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Measurement Without} \\ \text{Project} \end{array} = 1.0((0.30 \times 3) + (0.40 \times 3) + (0.30 \times 3)) = 3.0$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Construction} \end{array} = 0.50((0.30 \times 3) + (0.40 \times 6) + (0.30 \times 3)) = 2.1$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Use} \end{array} = 0.50((0.30 \times 3) + (0.40 \times 6) + (0.30 \times 3)) = 2.1$$

Total weighted estimate with project = 4.2.

For this parameter the EQ determined from Fig. 67 is:

$$\text{"Without" EQ} = 0.35$$

$$\text{"With" EQ} = 0.40$$

Therefore, the environmental impact on Mystery is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (4 \times 0.40) - (4 \times 0.35) \\ &= (1.60) - (1.40) \\ &= +0.2 \end{aligned}$$

"Oneness" With Nature

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Measurement Without} \\ \text{Project} \end{array} = 1.0((0.30 \times 1) + (0.40 \times 1) + (0.30 \times 1)) = 1.0$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Construction} \end{array} = 0.50((0.30 \times 1) + (0.4 \times 4) + (0.30 \times 1)) = 1.1$$

$$\begin{array}{l} \text{Weighted Parameter} \\ \text{Estimate With} \\ \text{Project-Use} \end{array} = 0.5((0.3 \times 1) + (0.4 \times 4) + (0.3 \times 1)) = 1.1$$

Total weighted estimate with project = 2.20.

For this parameter the EQ determined from Fig. 67 is:

"Without" EQ = 0.10

"With" EQ = 0.20

Therefore, the environmental impact on "Oneness" With Nature is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.2) - (11 \times 0.1) \\ &= (2.2) - (1.1) \\ &= +1.1 \end{aligned}$$

The low without project values were based on the identification with an empathy for weedy fields, the predominant element at, above and below the project site.

Life Patterns

The development of the Aubrey Reservoir project will have impacts affecting the lives of those people presently living in the proposed reservoir site, as well as on those people living adjacent to the site. Also, there will be some impact on those living in the upstream and downstream areas. The studies are designed to bring attention to the trend of impact; that is, the beneficial or adverse effect of the project on life patterns of human society. Three parameters, Employment Opportunities, Housing, and Social Interactions, express the impact on society caused by the Aubrey water resource development.

Employment Opportunities

Man has created employment in the proposed reservoir site in plant and animal, mining, contract construction, commerce, service and manufacturing industries. (Based

on the Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, U. S. Government Printing Office, Washington, D. C.).

The plant and animal industries in this study include the major groups of agriculture and forestry. The agricultural operation consists of employment in the production of crops or plants and trees (excluding forest operation), the keeping, grazing, and feeding of domesticated animals. Within the proposed reservoir there presently exist: cropland (3,861 acres), old field (26,635 acres), and forest (4,554 acres). All of the old field and forest lands are presently or recently used for grazing of livestock. The forestry operation offers employment opportunities in cutting of firewood, removal of native trees for landscaping, and harvesting of native pecans.

Mining industry is the extraction of economic minerals occurring in the area. It includes quarrying and well operation. Within the area exist a small producing oil field, sand and gravel quarries, and quarrying of some topsoil.

Contract construction refers to the construction of new work, additions, alterations, and repair of immobile structures. This includes the construction of houses, farm buildings, roads, bridges, railroads, farm ponds, well drilling, telephone lines, transmission lines, pipelines.

Commerce industries are those establishments primarily engaged in facilitating the ownership transfer of property. Within the reservoir site is a salvage yard and an antique shop.

Service industries are those establishments that are primarily engaged in providing benefits that are directed towards the buyer's person or property. There exist within the reservoir site one automotive repair shop, one welding shop, one American Legion hut, one church, a baseball camp for boys, and a retreat.

Manufacturing industries give form utility to raw materials. The only manufacturing is associated with the welding establishment. The owner-operator does manufacture some items used in rural areas, such as steel gates and livestock feeders.

In order to make a judgement of the EQ of employment opportunity, data were obtained by interviewing residents in the project site and recording the information on

questionnaires. Another basis for existing employment was derived from actually observing the existing employment.

The entire area is rural with rural type of land uses. There are no hamlets, villages, or towns in the reservoir site, although there exists what might be called a road-side - an automobile garage and welding shop operating full time. An antique shop is seldom operating. Only one church offers employment to a minister. In the interviews, employment data was collected from 59 households out of 69 dwellings which are located within the flood pool level. A part of the dwellings are not occupied the year around, being used on weekends or less frequently. A few of the permanent residents refused to give information. With the sampling obtained, the following data were recorded:

Present Employment Data from 67 Dwellings
in Reservoir Site

Full Employment in Reservoir Site

| | |
|----------|--|
| (1.5%) | 1 - Full-Time Business |
| (3.0%) | 2 - Part-Time Business and Part-Time Agriculture |
| (28.34%) | 19 - Full-Time Agriculture |
| Total | (32.84%) 22 |

Part-Time Employment in Reservoir Site

(31.35%) 21 - Part-time employment in Agriculture in reservoir site with balance of employment outside of reservoir site.

Of the 21 who have employment, both in the reservoir and outside, 19 of these receive 25% or less of their income from employment in the reservoir site; 1 receives approximately 50%; and 1 receives 75%.

No Employment in the Reservoir Site

| | |
|----------|---|
| (28.34%) | 19 - No income from within the reservoir site, but commute to work outside of the reservoir site. |
| (7.3%) | 5 - Retired |
| Total | (35.64%) 24 |

As a result of the survey, only 33% of those living in the reservoir site have full employment in the area, while less than 33% receive only a part of their income within the reservoir site and more than 33% derive no income from within the reservoir. From observations upstream, downstream and adjacent to the proposed reservoir site a similar employment pattern exists.

This is an area of extensive agriculture practices. Most of the area is used for grazing of beef cattle; areas of suitable soils and not so subject to flooding grow mostly small grains and hay crops. No irrigation was observed. Within the farmsteads, some 32 had home gardens; 8 had small orchards; 11 had poultry; 2 had milk cows; 3 had hogs; and 2 had beef cattle to fatten for home use. The agricultural development in the farmstead supplements incomes. There are three dairy operations in the reservoir site. Some additional income is derived through gas and oil lease and the sale of sande and gravel, firewood, and native pecans.

A part of the land is owned and operated by persons living in communities away from the reservoir site. These owner-operators live in such places as Pilot Point, Denton, and Dallas. Many of them gain only part of their income from lands in the reservoir site.

Employment opportunities for those residents adjacent to the project are similar to those within the reservoir project. Some residents, living adjacent to the reservoir site will lose a portion of their land to the project. There is no way of predicting this employment loss until the survey has been made and the amount of land needed for operation of the project determined.

By using the function graph (Fig. 68) employment opportunity changes can be noted. Values have been assigned

to the vertical axis and to the horizontal axis. The vertical axis expresses EQ with values ranging from 0 to 1.0, while the horizontal axis indicates the parameter scale of change with assigned values of 0 to 10. The values from 0 to 6 indicate the amount of disruption. "Disruption to existing" refers to any disruption the project may cause to the existing employment opportunity. The degree of disruption is indicated as high (values 0-2), medium (values 2-4), and low (values 4-6). "Improving" refers to any improvement over the existing employment that may result from the project with a value of 8 to 10. "Existing" is the present level of employment, that is, employment without the project. Existing employment is given a value range of 6 to 8. Therefore, it is possible to indicate the direction of change from present to the improvement or disruption with the construction and operation of the proposed Aubrey Reservoir. The transformation of employment opportunity estimates into environmental quality is achieved through the use of a value function which relates to various levels of employment estimates to the appropriate EQ levels.

In evaluating employment opportunities impacts created by the project, the study must consider both spatial and temporal aspects of the proposed development. Spatial patterns include the project site, upstream, and downstream sectors, while the temporal aspect must be evaluated as to existing (without project) construction and use conditions of the project.

Both spatial and temporal patterns are assigned relative importance values. Each spatial sector is given a weight to indicate its RI within that sector. The reservoir sector is assigned $RI = 0.6\%$ because of the direct impact on employment opportunities. The upstream and downstream sectors are assigned equal importance of $RI = 0.2$ each. As to the time patterns, the existing (without the project) is given an $RI = 1.0$ and with the project (construction and use) is given an $RI = 1.0$. The RI with the project is weighted between construction and use. An $RI = 0.25$ has been assigned to the construction period since this is a short-term impact, and 0.75 is assigned to the use period, a long-term impact.

First, each sector must be given an "existing" rating of between 6 and 8 (Fig. 68). In the case of the Aubrey project a rate of 7 is given. They were rated 7 rather than

6 because the area is a developed rural area. A rating of 6 would indicate an area of low development. The sectors were not rated 8 because the area is not highly developed--as urban or intensive agriculture employment would indicate--and also, most people living in the site area do not receive all of their income from within the project site.

Second, each sector with project construction and with project use is given a rating. With project construction, the upstream and downstream sectors will remain appreciably unchanged from the existing employment opportunities. Therefore, a rating of 7 is assigned. But at the reservoir site a rating of 9 is given. This improvement is indicated because of the following employment opportunities during construction:

1. Construction of dam and spillway (persons employed--workers on dam to office personnel)
2. Supplies of materials (raw)
3. Transportation of materials (raw)
4. Equipment used at site (operators)
5. Clearing of trees
6. Moving of utilities (telephone lines and poles, transmission lines and poles, pipelines)
7. Removal of bridges
8. Removal of buildings
9. Removal of railroad and building at a new site
10. New road construction
11. Improving old roads and bridges leading to reservoir
12. Construction and development of recreational facilities
13. Removal and relocating cemeteries

During the early part of the project construction, some employment presently in the reservoir site upstream from the dam will continue; therefore, with the construction bringing in a large number of employees plus a portion of the present employment continuing, employment opportunities during the construction will greatly increase. As construction is completed, employment opportunities will reach low ebb.

Once the project is complete and in use very little employment will exist within the reservoir project site boundary. There will be the possibility of such employment in boat service, operation of concessions, road and park

upkeep, and grazing. The existing plant and animal, service, commerce, manufacturing, and construction industries would be disrupted. Therefore, the reservoir sector is given a "with use" rating of 3. Upstream, there should be a small amount of construction and commerce develop. This could be employment in construction of houses and retail buildings and commerce in the operation of retail establishments selling food, fishing supplies, and automobile supplies. There could develop a cafe, and/or a motel, and boat sales and services. A rating of 8 is given. The project description predicts improvements downstream. This will increase employment opportunities. Therefore, the downstream sector is rated 9. There can develop in the downstream sector similar employment opportunities as in the upstream sector, but the greatest employment opportunity will result from the supplying of water to the cities of Denton and Dallas. Also, the flood control provided in the project will allow increased farming below the dam.

Input of these considerations into worksheet-matrix and calculations below yielded a total impact index of the Aubrey Reservoir Project of -1.365 EIU on Employment Opportunity. The following calculation of the reservoir project site is based on the project site boundary.

Weighted Parameter Considering Project Boundary for Site Sector:

Weighted Parameter
Assigned Without Project $= 1.0((0.2 \times 7) + (0.6 \times 7) + (0.2 \times 7)) = 7.0$

Weighted Parameter
Estimate With Project-Construction $= 0.25((0.2 \times 7) + (0.6 \times 9) + (0.2 \times 7)) = 2.05$

Weighted Parameter
Estimate With Project-Use $= 0.75((0.2 \times 8) + (0.6 \times 3) + (0.2 \times 9)) = 3.9$

Total weighted estimates with project = 5.95.

For this parameter the EQ determined from Fig. 68 is:

"Without" EQ = 0.700
"With" EQ = 0.595

Therefore, the environmental impact on Employment Opportunities is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (13 \times 0.595) - (13 \times 0.7) \\ &= (7.74) - (9.10) \\ &= -1.36 \end{aligned}$$

In analyzing the reservoir site sector, there are reasons that the impact should not be limited to the project site boundary. A more realistic approach, because of the geographic location of the project, is that consideration of the reservoir site sector should be extended horizontally at least 0.5 mile beyond the project boundary or even westward to Interstate Highway 35 and eastward to U. S. Highway 377.

Employment opportunities, because of the reservoir, will develop adjacent to or surrounding the project boundary for at least one-half mile horizontally beyond the project boundary. Within this area where sites are available and suitable there will be construction employment housing and service buildings and roads. Also, there will be employment in operating the commerce and service establishments and maintenance of roads.

Based on observation trends associated with other reservoir projects in this area, houses will be constructed by individuals on single plots and in areas created by land development companies. Within areas platted by land companies, several tens or even a few hundreds of houses will be constructed. This necessitates the construction of roads and providing utilities. The actual construction of houses gives employment to such as foundation workers, carpenters, plumbers, electricians, roofers; bricklayers, painters, and cabinet makers. This will require the providing of water and proper sewage disposal facilities. Normally, within the area there will develop such retail establishments as providing groceries, fuels, fishing equipment and supplies, some wearing apparel, and picnic supplies. Other establishments, such as cafes, motels, and boat sales, services, and storage offer employment opportunities. These all come into existence as an impact of the reservoir. Therefore, for the

15 year use period a value of 7 has been assigned to the reservoir site to 0.5 mile horizontally beyond the project boundary. The build-up in this area will create an employment opportunity at least as great as exists in the reservoir site at the present time.

Weighted Parameter Considering 1.5 Mile Horizontally Beyond Project Boundary:

Weighted Parameter
Assigned Without Project $= 1.0((0.2 \times 7) + (0.6 \times 7) + (0.2 \times 7)) = 7.0$

Weighted Parameter
Estimate With Project-Construction $= 0.25((0.2 \times 7) + (0.6 \times 9) + (0.2 \times 7)) = 2.05$

Weighted Parameter
Estimate With Project-Use $= 0.75((0.2 \times 8) + (0.6 \times 7) + (0.2 \times 9)) = 5.7$

Total weighted estimates with project = 7.75.

For this parameter the EQ determined from Fig. 68 is:

"Without" EQ = 0.700

"With" EQ = 0.775

Therefore, the environmental impact on Employment Opportunities is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (13 \times 0.775) - (13 \times 0.7) \\ &= (10.08) - (9.10) \\ &= +0.975 \end{aligned}$$

The Aubrey Reservoir will have some impact extending east and west of the project to the two highways which parallel the reservoir site. To the east of the proposed project is U. S. Highway 377. This highway parallels the east boundary of the project at no point more than miles' distance, and the highway will cross Buck Creek and Range Creek

arms of the reservoir. Located along Highway 377 are the towns of Pilot Point 1 2/3 miles from the Isle du Bois arm and Tioga within 3/4 mile of Buck Creek, 2/3 mile of Isle du Bois, and two miles of Range Creek arm. To the west is Interstate 35, a maximum distance of approximately 5 miles. Located on I-35 are the towns of Sanger and Valley View. Sanger will be 3 2/3 miles distant from the Elm Fork of the Trinity arm of the proposed reservoir. All four towns are presently served by hard surface roads to the reservoir site. The completed reservoir will have some employment opportunity impact on the four towns. There can be house construction and more service station operations and store operations selling supplies of food, wearing apparel, and fishing equipment and supplies. Due to the slight impact extending to the two mentioned highways and four towns, a value of 8 has been assigned for the project site. This is a slight improvement over present employment opportunity.

Weighted Parameter Considering West to and East to U. S. 377:

| | |
|--------------------|-------------------------------|
| Weighted Parameter | |
| Assigned Without | = 1.0((0.2 x 7) + (0.6 x 7) + |
| Project | (0.2 x 7)) = 7.0 |

| | |
|----------------------|--------------------------------|
| Weighted Parameter | |
| Estimate With | = 0.25((0.2 x 7) + (0.6 x 9) + |
| Project-Construction | (0.2 x 7)) = 2.05 |

| | |
|--------------------|--------------------------------|
| Weighted Parameter | |
| Estimate With | = 0.75((0.2 x 8) + (0.6 x 8) + |
| Project-Use | (0.2 x 9)) = 6.15 |

Total weighted estimates with project = 8.20.

For this parameter the EQ determined from Fig. 68 is:

| | |
|-----------|-----------|
| "Without" | EQ = 0.70 |
| "With" | EQ = 0.82 |

Therefore, the environmental impact on Employment Opportunities is:

$$\begin{aligned}
EIU &= (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}}) \\
&= (13 \times 0.82) - (13 \times 0.7) \\
&= (10.66) - (9.10) \\
&= +1.56
\end{aligned}$$

It is our opinion that this impact index should be used in determining the total impact of the Aubrey Reservoir Project.

Housing

Housing includes the site of residence. This may be a single house or it may be a farmstead-the house, yard area, and all buildings surrounding the house. Also included are any other buildings in the project area. This is a rural area with no housing clusters as observed in a hamlet, village, town, or city.

In order to make an EQ housing judgement, data were obtained through interviews and field observations. The existing housing in the reservoir site is about average density for a rural area of this region. There are approximately 280 buildings in the project boundaries. Of these, 63 are houses lived in, 6 mobile homes, 14 vacant houses, and 21 abandoned houses. In addition, there is an American Legion building, a mobile office, a garage and welding building, and a baseball camp with three buildings (plate IV). Others are buildings associated with farmsteads.

The value function graph (Fig. 68) for Housing has the same design as the function graph for Employment Opportunities (Fig. 68). On the function graph existing housing on the scale of change has a value of 6 to 8. Since this rural area has a moderate housing development, an average value of 7 is assigned to the upstream, site, and downstream sectors. With the project there would be a high disruption to the reservoir site sector. During construction of the project there will be a gradual disruption. The first removal of buildings will be in the dam site area, but by

the time construction is completed all buildings will be removed. So the high disruption reaches zero for both the construction period and the use period. This will necessitate the relocation of all families living in the project site and the removal of all buildings from the project site.

During the construction period it is anticipated that there should be no change in the upstream and downstream sectors. But, during the use period there is the possibility of a slight increase in the number of houses in the upstream and downstream sectors because of some families' wishing to build near the reservoir.

The reservoir site is given an RI = 1.0 because the site is the only sector in the Aubrey Reservoir project where housing will be significantly affected. The project will cause 100% disruption within the project boundary of the reservoir site. Input of the above considerations into the worksheet-matrix with calculations yielded a total impact index of the Aubrey Reservoir project of a -9.1 EIU on the Housing parameter.

Weighted Parameter
Measurement Without Project $= 1.0((0 \times 7) + (1 \times 7) + (0 \times 7)) = 7.0$

Weighted Parameter
Estimate With Project-Construction $= 0.5((0 \times 7) + (1 \times 0) + (0 \times 7)) = 0$

Weighted Parameter
Estimate With Project-Use $= 0.5((0 \times 7.5) + (1 \times 0) + (0 \times 7.5)) = 0$

Total weighted parameter estimate with project = 0.

For this parameter the EQ determined from Fig. 68 is:

"Without" EQ = 0.70
"With" EQ = 0

Therefore, the environmental impact on the Housing is:

$$\begin{aligned}
EIU &= (PIU \times EQ_{\text{with}}) - (PIU \times EQ_{\text{without}}) \\
&= (13 \times 0) - (13 \times 0.7) \\
&= (13) - (9.10) \\
&= -9.1
\end{aligned}$$

$$\begin{aligned}
\% \text{ EQ change} &= \frac{\text{"With" EQ} - \text{"Without" EQ}}{\text{"Without" EQ}} \times 100 \\
&= \frac{0 - 0.7}{0.7} \times 100 \\
&= -100\% \quad \text{which is a "Major Red Flag"}.
\end{aligned}$$

A more realistic approach to the housing parameter is to consider not only the site but also the project boundary horizontally to 0.5 mile. The existing housing values for the upstream, site, and downstream remain as average; that is, a value of 7. With construction of the project there would be a high disruption in project site, since all of these buildings will be removed and all families relocated. But within the 0.5 mile outside the project boundary these buildings and families would not be disrupted. Therefore, disruption value would be high, decreasing to an estimated value of 2 on the function graph. The upstream and downstream will remain unchanged from the existing. Following construction and during the use period of the project portions of the area within 0.5 mile of the project boundary will be an intensive build-up of houses as permanent dwellings, weekend and vacation cottages and some retail and service establishments. This build-up is predicted to total several hundred buildings-many more than presently exist in the reservoir site. The increase in number of buildings will result because of the reservoir. Therefore a value of 9 is assigned to the "with" project use for the project site and horizontally 0.5 mile beyond. Upstream and downstream sectors will probably have some slight increase in housing. The RI needs to be changed. Spatial RI values for upstream and downstream are assigned as 0.2 for each and 0.6 for the site sector. Time value without project remains at 1.0, but with project, the construction period

of RI is 0.25 and the use period given 0.75.

Input of these considerations into the worksheet-matrix and calculations for the upstream, downstream, and site to 0.5 mile beyond project boundary yield a total impact of the Aubrey Reservoir Project to = 0.39 EIU on Housing.

Weighted Parameter

Measurement Without Project $\approx 1.0((0.2 \times 7) + (0.6 \times 7) + (0.2 \times 7)) = 7.0$

Weighted Parameter

Estimate With Project-Construction $\approx 0.25((0.2 \times 7) + (0.6 \times 2) + (0.2 \times 7)) = 1.0$

Weighted Parameter

Estimate With Project-Use $\approx 0.75((0.2 \times 7.5) + (0.6 \times 9) + (0.2 \times 7.5)) = 6.3$

Total weighted estimate with project = 7.3.

For this parameter the EQ determined from Fig. 68 is:

"Without" EQ = 0.70

"With" EQ = 0.73

Therefore, the environmental impact on Housing is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (13 \times 0.73) - (13 \times 0.7) \\ &= (9.49) - (9.10) \\ &= +0.39 \end{aligned}$$

It is our opinion that the latter impact index should be used in determining the impact of the Aubrey Reservoir Project.

Social Interactions

Social interactions as a parameter is an effort to consider the impact of the reservoir project on activities which are a part of people's lives. This parameter includes interrelationships created by churches, clubs, schools, camps and retreats, entertainment, and recreational activities. The study also must consider travel and shopping patterns. The Aubrey Reservoir Project will certainly disrupt some of the interrelationships, but the project may also enhance some of the interrelationships and patterns.

Within the project area exist the following social activities that are an important part of people's lives: 1) a baseball camp for boys to learn baseball also provides recreation and the opportunity for the development of friendships; 2) a retreat area located northwest of Pilot Point provides facilities for recreation and relaxation; 3) the St. James Church is used for meetings and social functions; 4) at the Bloomfield Cemetery and church building, people gather to clear the cemetery of unwanted vegetation. The social value occurs as the people work and visit together, some people seeing each other only once a year. The people bring food and all eat together. This is the only time the church building is used; 5) bodies of water provide sites for recreation and use of leisure time. Many people fish in the streams and farm ponds and some swim here. There were observed sites for picnicing with tables and chairs or benches. Other values in recreation and use of leisure are hunting of native animal life and target practice; 6) friendships develop among neighbors in the rural areas, and also there develop friendships of the peoples of these rural areas with those in towns where the rural people shop; 7) there are no schools in the project area, but the children of school age attend school in such school districts as Sanger, Valley View, Pilot Point, and Tioga. In their respective schools exist their friends, and many of their social and recreational activities. With the construction of the project, many of these children may have to change school districts; 8) today there exists a more or less fixed road pattern which is used to travel to shopping centers, churches, schools, work, and social gatherings.

In order to make a judgement of social interaction, data were obtained through interviews, observations, and the study of maps. Without the Aubrey Reservoir Project the present kinds of social interactions will probably continue in their present patterns. With the project the social interaction will not be destroyed but only slightly disrupted, and in some cases there will be improvement. Such social programs as those associated with the baseball camp, retreat, and church would continue in association with the establishment if they are relocated on another site outside the reservoir project. In fact, if the baseball camp and retreat were located adjacent to the reservoir project, their value in social interaction could possibly improve. Certainly, their setting would be more attractive than at the present sites.

The leadership of the St. James Church have indicated that they would like to have the church nearer the members' dwellings. At present all members except one family live in Pilot Point. If the church were moved to where the people live, the building could be more actively used for social events. If the Corps of Engineers assists the owners in relocating, the disruption would be minimized to a short term period and the social interaction over the long term improved.

The movement of the Bloomfield Cemetery and church building could be done at a time when the families are not gathered to clean the cemetery grounds and to socialize in the church building, thereby causing no disruption or a very slight disruption at the most.

Presently, the bodies of water provide sites for recreation, use of leisure time, and picnicing mostly for a limited few who live in the reservoir site. The construction of the reservoir would greatly increase these uses to several million persons annually.

Friendships would be disrupted among neighbors and children of school age. There are 208 persons living in the proposed reservoir site, many of whom have close ties to their lands. Several families have lived at their present place more than 50 years and two families for 68 years. Some of the farms have been in the same family since

the late middle and late 1800's. The relocating of families would disrupt friendships. There are 46 school children. In relocating families some of the children would change school districts. This can be a great disruption to these children.

With the relocation of families, there will be some disruption to their shopping patterns, churches they attend, distance of travel to work and social activities associated at schools and other establishments. This can mean seeking new communities for shopping, new churches, new friends, rooting for a different football and basketball team. Many rural people are closely attached to the social, friendship, and athletic activities of their area. To some people the social interaction disruption will be short-lived, but to others the disruption will be everlasting. This close attachment to the area, of course, is probably strongest among the older people and those whose families represent several generations on the same land. By the end of the use period of the project, most of those people who see the greatest disruption probably will not be living.

A road pattern, travel and shopping habits for those living between the arm of the Elm Fork of the Trinity and the Isle du Bois will be disrupted. Today many of those people focus their economic and social activities southward to Denton, Sanger, and Pilot Point. When the reservoir is completed, they will have to travel a greater distance (Plate V) to Denton, Sanger, and Pilot Point. More of them will probably shift their activities toward Gainesville.

The value function graph (Fig. 68) for Social Interaction has the same design as the function graph for Employment Opportunities.

In evaluating the social interactions impact created by the project, the study must consider both space and time aspects of the proposed development. Both time and space patterns are assigned RI values to represent their importance within each sector. An RI for spatial distribution was assigned as follows: upstream 0.15, reservoir site 0.80, and downstream 0.5. These indicate that the greatest disruption impact will take place in the reservoir site. Upstream social disruption will be slightly greater than that of downstream. Upstream, those people on the peninsula between the Elm Fork of the Trinity arm and the Isle du Bois

arm of the reservoir will tend to be somewhat isolated from social activities and shopping habits in Sanger, Pilot Point and Denton.

Time RI values are 1.0 without project and 1.0 with project. Because the construction period with project is short termed, an RI = 0.25 is assigned, and the long-termed use period is given an RI = 0.75.

Without the project an average or medium value of 7 is assigned for upstream, site, and downstream. During the construction period, low disruption will occur upstream because the people upstream between the two major arms of the reservoir will be cut off from a number of their interrelationships and patterns to the south. Therefore, a value of 5 is assigned. Disruptions downstream will not occur. The greatest disruption will occur in the reservoir site sector, so a value of 2 is given, although with the construction and use of the project, as has been indicated, the project will enhance certain aspects of relationships. It will greatly increase recreational and leisure time opportunities. The moving of some of the present establishments such as the church, the baseball camp, and retreat may increase their use. The project could result in increased interrelationships. Even though many families' social interrelationships will be disrupted during construction, they will develop other social interrelations and patterns and during the use period most of the nostalgia for the area will cease to matter for many.

Some families would not have too great a social tie to the area or nostalgia toward the land. There are 19 families that are renters and half of them gain none of their livelihood from the land on which they live. Part of the land has no one living on it. The owners, for the most part, live outside the project area in communities in north central Texas. There are 21 abandoned houses in the area. Some 36 families have lived in their present houses less than 10 years. A few families have only weekend houses. Therefore, when the disruptions are weighed against the enhancement of social interactions, in our opinion, the use of the project will bring an improved use impact in the project site. A value of 9 is assigned for the social interactions.

Input of these considerations into the worksheet-matrix and calculations below yielded a total impact index of the

Aubrey Reservoir Project to +0.14 EIU on the Social Interactions.

Weighted Parameter

Measurements Without = $1.0((0.15 \times 7) + (0.8 \times 7) +$
Project $(0.05 \times 7)) = 7.0$

Weighted Parameter

Estimate With = $0.25((0.15 \times 5) + (0.8 \times 2) +$
Project-Construction $(0.05 \times 7)) = 0.675$

Weighted Parameter

Estimate With = $0.75((0.15 \times 7) + (0.8 \times 9) +$
Project-Use $(0.05 \times 7)) = 6.45$

Total weighted estimate with project = 7.125.

For this parameter the EQ determined from Fig. 68 is:

"Without" EQ = 0.7000

"With" EQ = 0.7125

Therefore, the environmental impact on Social Interactions is:

$$\begin{aligned} \text{EIU} &= (\text{PIU} \times \text{EQ}_{\text{with}}) - (\text{PIU} \times \text{EQ}_{\text{without}}) \\ &= (11 \times 0.7125) - (11 \times 0.7) \\ &= (7.84) - (7.70) \\ &= +0.14 \end{aligned}$$

Conclusions of Life Patterns

Analyzing the life patterns of employment opportunities, housing, and social interactions in the Aubrey Reservoir area discloses there will be disruptions and hardships of varying degrees. For the long-term use of the project, the environmental impact unit will be a plus; the area will be enhanced. The disruption will be greatest on those families living within the project boundary sector. Those families

who have lived on the land for 40, 50, and 60 years and those whose land has been in the family for several generations and those families who have put their life's work into building productive agricultural operations will be most disrupted.

There should be included in the study a parameter expressing the feelings and attitudes of the people living in the reservoir sector. While doing field work in the project area, 56 families living within the proposed project boundaries expressed their feeling toward the project. Their attitudes are as follows: 1) definitely against the project = 27; 2) rather not have the project but accept the project if it is really needed = 14; 3) do not care = 12; and 4) for the project = 3. They expressed opinions as, "If they (the Corps of Engineers) will just treat me fairly," "The project is good for the future, but we also need good farmland," "We would like to know something for sure; we cannot sell our land and cannot buy another place outside of the project area," and "By the time the reservoir is built, the land in this general area will be so high priced, we cannot buy it with the money the Corps pays for our land." Then there were those persons who expressed just "definitely against" and "no." Most of the people are frustrated by the uncertainty, the waiting, how are they going to be treated, will the Corps of Engineers be fair, how much will they be paid, and when. Many are frustrated because now they cannot sell their land. If a good opportunity presents itself to buy land outside of the reservoir project, they do not have the money to do so and cannot do so until their land is purchased. A sampling of 22 families were interviewed who live around the project perimeter and who have land extending into the area they expressed a similar attitude to those living within the project boundary.

The Corps of Engineers needs to be in a position to take the leadership to help these families through this period of frustration and confusion and to assist those families who wish assistance in financing them and relocating them.

Summary of the EES Evaluation of the
Environmental Impact of the Aubrey Reservoir
Project on Ecology, Environmental
Pollution, Esthetics and Human Interest

Tables 9 through 13 provide a summary of the results we obtained by using the Battelle-Columbus EES to evaluate the environmental impact of the Aubrey Reservoir project. The following are important to understanding the tables (see section on Description of EES for more information):

1. Parameter Importance Units (PIU) = absolute numerical importance of a given parameter based on a total of 1000 points apportioned among 78 EES parameters.
2. Environmental Quality (EQ) = a normalized or scaled quality range of 0-1 (0 = extremely poor and 1 = maximum quality) for each parameter.
3. Environmental Impact Units (EIU = EQ X PIU) for a given parameter with or without a project. This essentially represents the fraction of the absolute maximum PIU a parameter is currently worth (with or without the project). The difference between a parameter's "with" and "without" EIU's ($EIU_{with} - EIU_{without}$) = the environmental impact of a project in EIU's. Negative (-) EIU changes generally suggest adverse environmental effects, whereas positive (+) changes usually indicate beneficial effects of a project on the parameter. The sum of the positive and negative EIU changes for the 78 parameters = the Environmental Impact Index for the project.
4. "Red Flags" are used to indicate extremely fragile environmental parameters which are likely to be adversely affected by a project and/or to indicate further data needs. "Red Flags" are used here to both point out fragile parameters and to indicate parameters for which adequate quantitative data were unavailable at the time this report was prepared. Essentially, they point out potential problems to the Army Corps of Engineers which

should be considered in design, construction and use of the Aubrey Reservoir.

The overall Environmental Impact Index or net EIU change (+1.74) shown in Table 13 indicates that the Aubrey Reservoir Project will have a slightly positive impact on the environmental parameters in the EES. According to the results of the EES, the benefits derived from the reservoir slightly more than "compensate" for the losses. Therefore, considering only the parameters examined, the EES results offer no major objection to constructing the Aubrey Reservoir.

However, the Army Corps of Engineers should be cognizant of the "Red Flags" and our recommendations. They should be carefully considered during the planning, construction and use of the reservoir.

Since our application of the EES represents its second field test, the impact index has little comparative value at this time. Battelle-Columbus (1) field-tested the EES on two segments of the Bear River Project in Utah, Idaho, and Wyoming: Oneida Narrows and Honeyville segments. The results of their tests are shown below.

| <u>Oneida Narrows</u> | "With" | "Without" | Net EIU Change |
|-------------------------------|-----------|-----------|-------------------|
| Ecology | 96 | 96 | 0 |
| Environmental Pollution | 195 | 201 | -6 |
| Esthetics | 56 | 60 | -4 |
| Human Interest | <u>49</u> | <u>66</u> | <u>-17</u> |
| Total | 396 | 423 | -27 |
| (32 Red Flags and data needs) | | | |

| <u>Honeyville</u> | "With" | "Without" | Net EIU Change |
|-------------------------------|-----------|-----------|-------------------|
| Ecology | 81 | 81 | 0 |
| Environmental Pollution | 203 | 204 | -1 |
| Esthetics | 56 | 48 | +8 |
| Human Interest | <u>33</u> | <u>47</u> | <u>-14</u> |
| Total | 373 | 380 | -7 |
| (30 Red Flags and data needs) | | | |

Comparison of these results with ours shows that the Aubrey Reservoir Project has both fewer "Red Flags" and data needs, than the two segments of the Bear River Project. However, it is unrealistic to draw conclusions from comparison of impact indices from the Bear River Projects with that for the Aubrey Project at this time for at least two reasons: 1) the EES system is virtually brand-new and 2) two different teams employed it in totally different geographic regions.

Although we are confident in our use of the Battelle-Columbus EES in assessing the impact of the Aubrey Reservoir Project we anticipate extensively modifying the EES for future impact studies within The Trinity River Basin. The Battelle-Columbus EES is a significant advancement in techniques for evaluating environmental impacts. However, we believe this instrument should be "tailored" to major geographic regions and only used for comparison among projects and alternatives within a single region. Having several versions of the EES with regional applicability is more realistic than a single version. Comparison among projects and their alternatives within a region is more meaningful than between different regions.

Several of our recommendations are found under GENERAL RECOMMENDATIONS.

TABLE 9. Summary of the EES Evaluation of the Environmental impact of the Aubrey Reservoir Project on Ecology

| Environmental Parameter | Weight (PIU) | With Project (EIU) | Without Project (EIU) | Net Change (EIU) | Red Flags | |
|-----------------------------------|--------------|--------------------|-----------------------|------------------|-----------|-------|
| | | | | | Minor | Major |
| <u>Species & Populations</u> | | | | | | |
| (Terrestrial) | | | | | | |
| Browsers & Grazers | 14 | 2.80 | 11.76 | -8.96 | | X |
| Crops | 14 | 0.00 | 5.70 | +5.70 | | X |
| Natural Vegetation | 14 | 0.00 | 4.34 | -4.34 | | X |
| Pest Species | 14 | 10.50 | 5.88 | +4.62 | | |
| Upland Game Birds | 14 | 0.21 | 0.87 | -0.66 | | X |
| (Aquatic) | | | | | | |
| Commercial Fisheries | 14 | 4.54 | 0.003 | +4.537 | | |
| Natural Vegetation | 14 | 1.12 | 0.08 | +1.04 | | |
| Pest Species | 14 | 7.00 | 8.40 | -1.40 | | X |
| Sport Fish | 14 | 6.06 | 0.04 | +6.02 | | |
| Waterfowl | 14 | 8.82 | 4.62 | +4.20 | | |
| <u>Habitats & Communities</u> | | | | | | |
| (Terrestrial) | | | | | | |
| Food Web Index | 12 | 0.84 | 7.92 | -7.08 | | X |
| Land use | 12 | 5.52 | 3.96 | +1.56 | | |
| Rare & Endangered Species | 12 | 6.00 | 12.00 | -6.00 | | X |
| Species Diversity | 14 | 0.00 | 0.91 | -0.91 | | X |
| (Aquatic) | | | | | | |
| Food Web Index | 12 | 6.72 | 6.96 | -0.24 | | |
| Rare & Endangered Species | 12 | 12.00 | 12.00 | 0.00 | | |
| River Characteristics | 12 | 6.36 | 7.80 | -1.44 | | X |
| Species Diversity | 14 | 7.56 | 8.82 | -1.26 | | X |
| Total | 240 | 86.05 | 102.06 | -16.01 | 0 | 10 |

Table 10. Summary of the EES evaluation of the environmental impact of the Aubrey Reservoir Project on Environmental Pollution

| Environmental Parameter | Weight (PIU) | With Project (EIU) | Without Project (EIU) | Net Change (EIU) | Red Flags | |
|-------------------------|--------------|--------------------|-----------------------|------------------|-----------|-------|
| | | | | | Minor | Major |
| <u>Water Pollution</u> | | | | | | |
| Basin Hydrologic | | | | | | |
| Loss | 20 | 19.60 | 19.60 | 0.00 | | |
| BOD | 25 | 20.00 | 12.50 | +7.50 | | |
| Dissolved Oxygen | 31 | 27.90 | 29.45 | -1.55 | | |
| Fecal Coliforms | 18 | 9.00 | 9.00 | 0.00 | | |
| Inorganic Carbon | 22 | 22.00 | 22.00 | 0.00 | | |
| Inorganic Nitrogen | 25 | 24.25 | 20.00 | +4.25 | | |
| Inorganic Phosphate | 28 | 0.00 | 0.00 | 0.00 | | |
| Pesticides | 16 | 6.40 | 8.00 | -1.60 | X | |
| pH | 18 | 16.20 | 16.20 | 0.00 | | |
| Stream Flow | | | | | | |
| Variation | 28 | 28.00 | 28.00 | 0.00 | | |
| Temperature | 28 | 26.60 | 28.00 | -1.40 | | |
| Total Dissolved Solids | 25 | 23.75 | 23.75 | 0.00 | | |
| Toxic Substances | 14 | 14.00 | 14.00 | 0.00 | | |
| Turbidity | 20 | 3.00 | 2.00 | +1.00 | | |
| <u>Air Pollution</u> | | | | | | |
| Carbon Monoxide | 5 | 5.00 | 5.00 | 0.00 | | |
| Hydrocarbons | 5 | 5.00 | 5.00 | 0.00 | | |
| Nitrogen Oxides | 10 | 10.00 | 10.00 | 0.00 | | |
| Particulate Matter | 12 | 12.00 | 12.00 | 0.00 | | |
| Photochemical | | | | | | |
| Oxidants | 5 | 5.00 | 5.00 | 0.00 | | |
| Sulfur Oxides | 10 | 10.00 | 10.00 | 0.00 | | |
| Other | 5 | 5.00 | 5.00 | 0.00 | | |
| <u>Land Pollution</u> | | | | | | |
| Land Use | 14 | 5.60 | 11.48 | -5.88 | | X |
| Soil Erosion | 14 | 9.94 | 8.12 | +1.82 | | |
| <u>Noise Pollution</u> | | | | | | |
| Noise | 4 | 0.87 | 2.40 | -1.53 | | X |
| Total | 402 | 309.11 | 306.50 | +2.61 | 1 | 2 |

Table 11. Summary of the EES evaluation of the environmental impact of the Aubrey Reservoir Project on Esthetics

| Environmental Parameter | Weight (PIU) | With Project (EIU) | Without Project (EIU) | Net Change (EIU) | Red Flags | |
|---------------------------------|--------------|--------------------|-----------------------|------------------|-----------|-------|
| | | | | | Minor | Major |
| <u>Land</u> | | | | | | |
| Geologic Surface Material | 6 | 1.20 | 0.84 | +0.36 | | |
| Relief & Topographic Character | 16 | 0.32 | 0.32 | 0.00 | | |
| Width & Alignment | 10 | 3.14 | 1.90 | +1.24 | | |
| <u>Air</u> | | | | | | |
| Odor and Visual | 3 | 2.70 | 2.70 | 0.00 | | |
| Sounds | 2 | 0.20 | 1.10 | -0.90 | | X |
| <u>Water</u> | | | | | | |
| Appearance of Water | 10 | 4.32 | 4.00 | +0.32 | | |
| Land & Water Interface | 16 | 4.03 | 4.80 | -0.77 | | |
| Odor & Floating Materials | 6 | 3.24 | 2.40 | +0.84 | | |
| Water Surface Area | 10 | 7.24 | 1.25 | +5.99 | | |
| Wooded & Geologic Shoreline | 10 | 9.08 | 3.66 | +5.42 | | |
| <u>Biota</u> | | | | | | |
| Animals-Domestic | 5 | 2.00 | 4.50 | -2.50 | | X |
| Animals-Wild | 5 | 2.65 | 2.75 | -0.10 | | |
| Diversity of Vegetation Types | 9 | 3.60 | 3.15 | +0.45 | | |
| Variety Within Vegetation Types | 5 | 1.60 | 1.30 | +0.30 | | |
| <u>Man-Made Objects</u> | | | | | | |
| Man-made Objects | 10 | 3.60 | 3.90 | -0.30 | | |
| <u>Composition</u> | | | | | | |
| Composite Effect | 15 | 6.60 | 6.00 | +0.60 | | |
| Unique Composition | 15 | 0.00 | 0.00 | 0.00 | | |
| Total | 153 | 55.52 | 44.57 | +10.95 | 0 | 2 |

Table 12. Summary of the EES evaluation of the environmental impact of the Aubrey Reservoir Project on Human Interest

| Environmental Parameter | Weight (PIU) | With Project (EIU) | Without Project (EIU) | Net Change (EIU) | Red Flags | |
|--|-----------------|--------------------------|-----------------------------|------------------------|-----------|-------|
| | | | | | Minor | Major |
| <u>Educational/Scientific Packages</u> | | | | | | |
| Archeological | 13 | 3.12 | 7.80 | -4.68 | | X |
| Ecological | 13 | 10.40 | 7.80 | +2.60 | | |
| Geological | 11 | 6.60 | 2.20 | +4.40 | | |
| Hydrological | 11 | 8.88 | 6.66 | +2.22 | | |
| <u>Historical Packages</u> | | | | | | |
| Architecture & Styles | 11 | 0.22 | 2.20 | -1.98 | | X |
| Events | 11 | 2.86 | 2.20 | +0.66 | | |
| Persons | 11 | 2.20 | 1.10 | +1.10 | | |
| Religions & Cultures | 11 | 1.76 | 3.30 | -1.54 | | X |
| "Western Frontier" | 11 | 0.00 | 0.00 | 0.00 | | |
| <u>Cultures</u> | | | | | | |
| Indians | 14 | 0.00 | 0.00 | 0.00 | | |
| Other Ethnic Groups | 7 | 0.00 | 0.00 | 0.00 | | |
| Religious Groups | 7 | 4.20 | 4.20 | 0.00 | | |
| <u>Mood/Atmosphere</u> | | | | | | |
| Awe-Inspiration | 11 | 1.32 | 1.10 | +0.22 | | |
| Isolation/Solitude | 11 | 2.20 | 4.40 | -2.20 | | X |
| Mystery | 4 | 1.60 | 1.40 | +0.20 | | |
| "Oneness" with Nature | 11 | 2.20 | 1.10 | +1.10 | | |
| <u>Life Patterns</u> | | | | | | |
| Employment Oppor- tunities | 13 | 10.66 | 9.10 | +1.56 | | |
| Housing | 13 | 9.49 | 9.10 | +0.39 | | |
| Social Interactions | 11 | 7.84 | 7.70 | +0.14 | | |
| Total | 205 | 75.55 | 71.36 | +4.19 | 0 | 4 |

Table 13. Summary of the EES evaluation of the environmental impact of the Aubrey Reservoir Project on Ecology, Environmental Pollution, Esthetics and Human Interest

| Environmental Category | Weight (PIU) | With Project (EIU) | Without Project (EIU) | Net Change (EIU) | Red Flags Minor | Red Flags Major |
|-------------------------|--------------|--------------------|-----------------------|------------------|-----------------|-----------------|
| Ecology | 240 | 86.05 | 102.06 | -16.01 | 0 | 10 |
| Environmental Pollution | 402 | 309.11 | 306.50 | +2.61 | 1 | 2 |
| Esthetics | 153 | 55.52 | 44.57 | +10.95 | 0 | 2 |
| Human Interest | <u>205</u> | <u>75.55</u> | <u>71.36</u> | <u>+4.19</u> | <u>0</u> | <u>4</u> |
| Total | 1000 | 526.23 | 524.49 | +1.74* | 1 | 18 |

* Environmental Impact Index of the Aubrey Reservoir Project on four environmental categories.

Environmental Elements

This section of our Environmental Impact Statement contains reports on the following environmental elements: Botanical, Zoological, Archeological-Historical-Cultural, Geological, Hydrological-Water Quality and Demographical-Economical-Cultural.

These reports vary in depth of treatment according to the professional judgment of the investigators as to the relative importance of the elements, the availability of qualitative and quantitative data, the time limitations on the studies and the extent the material is covered in the EES section. Essentially the reports are designed to capture aspects of the environment associated with the Aubrey Reservoir site which were either missed or not covered sufficiently in the EES. This section, combined with the EES, is our attempt to provide a more comprehensive Environmental Impact Statement.

Botanical Elements

The conspicuous terrestrial botanical elements in the proposed Aubrey Reservoir site are natural physiognomic communities, each characterized by a unique assemblage of predominant species controlling the community through their superior competitive capacity. These communities are Hackberry-Cedar Elm Streamside Forest, Post Oak Upland Forest and the Purple three-Awn-Ragweed Abandoned Old Field (see Plate III).

The upland forest is restricted to Woodbine sandstone parent materials on which most of the reservoir site is located. A few miles to the east, Woodbine gives way to the Eagleford shale substrates. The vegetation likewise gives way sharply to the Blackland Prairie dominated by little bluestem. A few miles to the west, Woodbine is replaced by Grayson-Mainstreet-Paw-paw, and the Post Oak Forest changes sharply to the Grand Prairie.

The Post Oak Community is structurally simple. The controlling arborescent layer is dominated by one species, the long-lived post oak, Quercus stellata. The short-lived black-jack oak, Q. marylandica, may occur as a pioneer, particularly

following fire, but is competitively eliminated in a semi-disturbed or undisturbed stand within 50 years; its seedlings are shade-intolerant. Subdominants are discontinuous and few, lacking lateral control but maintaining high presence. These are Ulmus alata, winged elm and Carya texana, Texas hickory.

With alluvial dissection of the undulating Woodbine plain, two factors alter the vegetational pattern: 1) stream deposition which lays down fluvial silt and changes nutrient and ion retention, water-holding capacity, and gas exchange; and 2) spring and fall inundation of the flood plain.

The Flood Plain Forest is more complex laterally and vertically than the upland forest. It is dominated and controlled by southern hackberry, Celtis laevigata, on the low but high water-table terraces. Principal associates are burr oak, Quercus macrocarpa, and red ash, Fraxinus pennsylvanica. On the high and drier terraces, cedar elm, Ulmus crassifolia, predominates. Common associates are Gleditsia tricanthos, honey locust and Morus rubra, red mulberry.

Limited combinations of species from each forest type may occur. Upland Post Oak Forest may border on the stream bed if the topography is steep, and floodplain development restricted. Along runs and branches of the two major streams, cedar elm and post oak form an ill-defined co-dominate forest. On mesic, north-facing slopes in the upland forest, the elements of the drier portion of the floodplain may emerge in subordinate roles, principally cedar elm, red mulberry and poison ivy.

In both forests, the shrub and herb strata are discontinuous and strangely lacking in lateral cohesion. Coralberry, Symphoricarpos orbiculatus, is a desultory upland shrub, whereas no herb has consistent presence. In the lowland forest, Sambucus, the elderberry, indicates a closed high, near-climax upper forest canopy and Elymus canadensis forms a dense tangle if the crown is somewhat interrupted. Viola missouriensis, Ruellia strepens and Rivian humilis indicate near climax or good forest integrity depending on their quantitative values.

These two forests blanketed the reservoir site until settlers arrived in the 1830's and cleared the Upland Post Oak Forest (Eastern Cross Timbers) first for cultivation and domestic use. As the fragile A₁ soil layer of the upland cleared sites disappeared, the pioneers turned to the richer floodplains and spent the next 100 years pushing the forest back to the streambeds.

A new vegetation emerged in the abandoned upland old fields. These were complex weedy assemblages dominated mostly by aspect herbs which varied with grazing pressure and season. However, on drier sites purple three-awn, Aristida purpurea, persisted and on the more mesic sites, ragweed, Ambrosia artemesifolia, seemed to dominate among the many ruderals.

During this period post oak and bottomland species were used for heating and cooking fires. Biomass of these trees diminished until the 1930's when gas became available for fuel. The forests have not recovered from this pressure and one can rarely find a post oak over 8" DBH in the 120 miles of the Eastern Cross Timbers unless it is a dooryard tree or a corner marker. The new demand for fireplace wood by Dallas-Denton-Fort Worth metropolitan areas will continue to put pressure on the remaining trees.

Man's impact on the original 35,050 acres of forest (area of reservoir at the upper guide control) has been reduced eight-fold to 4,554 acres. Of course acreage depletion is only one gross measure of ecological alteration. Internal quantitative change is also a critical ecological alteration. Comparison of the two types of vegetation as they once were and as they are now will demonstrate the impact cultivation, grazing and use of trees for building and firewood have had.

The Celtis-Ulmus Association or the bottomland forest begins on new alluvium with such pioneers as Salix nigra, willow, Populus deltoides, cottonwood, and Platanus occidentalis, sycamore. These do not persist, as evidenced by only a few large individuals on the floodplain while juveniles abound on the scoured sides of the stream channel. Soon cedar elm germinates in the pioneer consolidation, seldom forming a distinct state as southern hackberry and red ash readily ecize as the forest floor darkens and pioneer reproduction ceases. The two-stage process proceeds to a climax plateau with subdominates appearing as forest biomass increases.

The best stand estimates of near-climax come from analysis of the forest at the confluence of Clear Creek and Elm Fork, just downstream from the proposed reservoir site. This stand was of difficult access and escaped some of the anthropic ravage of the last century. The arborescent layer of this stand was sampled with 22 ares (are = 100 square meters) set at 50 M intervals along transects projected from aerial photos. Comparative quantitation was also taken by reducing the ares to a line and considering crown interception for 10 M every 50 M.

The presence list and size class pattern of the components are given in Tables 14 and 15. Likewise, density, frequency, and biomass of each species are depicted in Tables 16 and 17. These data support the contention that the predominates are hackberry and cedar elm with good number, spatial distribution, biomass and age distribution characteristics. Note the high reproduction data for each, a prerequisite of a climax species in a closed forest.

The highly disturbed or reduced "fringe" stands within the impact area were sampled in the arms of Elm Fork and Isle du Bois above the dam site. Arborescent samples were taken by systematically placing ares along transects which were set by compass after aerial reconnaissance. Frutescent quadrats (16 centares; centare = 1 square meter) and herbaceous quadrats (1 centare) were nested in opposite ends of each arborescent are.

Pooled size classes from field data for the arborescent species are given in Table 18. From these are derived relative differences in numbers, frequency, number of size classes represented and relative differences in biomass as reflected in basal area calculations.

There is no real component dropout, but biomass reduction is apparent as is the preservation of pecan by selective cutting in the fringe forest. The forest is gravely wounded but would recover rapidly as evidenced by the reproductive plasticity of hackberry and cedar elm on the rich mud brought in each year by the spring floods if permitted to do so. Since the reservoir will probably reduce downstream flooding, regeneration of these Streamside Forests will be much slower even if grazing, cutting, etc., is stopped. Although a high percentage of species with low frequencies is characteristic of many mature systems, it is characteristic of maximum disturbance here, i.e., the heterogeneity prior to sorting by natural competition.

Since the bottom strata are dispersed discontinuously due to grazing, lateral continuity is lost and an association data table is useless. Bottomland shrubs encountered were Smilax bona-nox, Cocculus carolinus, Crataegus mollis, Sesbania drummondii, S. vesicaria, S. macrocarpa, Parthenocissis quinquefolia, Rhus copallina, Rhus toxicodendron and Symphoricarpus orbiculatus. Noteably absent was Sambucus canadensis, an indicator of near-climax and the principal shrub of the Clear Creek-Elm Fork stand.

The Quercus stellata Association or upland forest may not begin as pioneer subclimax stages on new parent material

as may the bottomland forest. Primary succession must have been a simple process. However, when openings occur in near-climax Post Oak Forest due to the death of a tree, replacement may be by post oak transgressives only.

Secondary succession may be by post oak, if the forest has been cleared and abandoned with some blackjack forest. Rarely, because of grazing, mid-grasses dominated by little bluestem precede the post oak consolidation of an upland old field. No little bluestem was found in the study area, a sign of extreme grazing pressure. If fire opens up or eliminates the upland forest, the first state is almost always blackjack scrub. But because of its short life, blackjack persists only because of the periodic fires during the late summer and fall. In essence the Post Oak Forest is dominated by post oak with few consorts and these coming in after the synfolium is well-established.

A best-stand analysis is hard to come by. A nearby climax stand studied some 20 years ago, probably was the best in the Eastern Cross Timbers. This stand was cleared some 10 years ago, but some data from it, particularly the presence list, may be compared with stand analyses from the western, central and eastern segments of the proposed reservoir site (Table 19). These data were taken with the same methods used in the bottomland forest section.

The first four arborescent species, post oak, blackjack oak, winged elm and Texas hickory, are the characteristic species of the Eastern Cross Timbers. Note the high presence values for each which indicate the four are found in nearly any segment of the forest evaluated along the length of the Eastern Cross Timbers. Those with lower presence occur in more mesic situations initiated physiographically (a north-facing slope) or by a lack of disturbance (closed forest canopy).

In the near-climax stand, the Post Oaks are evenly spaced (f-94) with a density of nine per are. Large specimens were present, as were all size classes--particularly reproductives because of a lack of grazing.

Note the low values for blackjack oak, typical of a species being replaced. Winged elm is a subdominant but competitively-suppressed as indicated by its density and frequency. All its size classes were all represented, whereas younger blackjacks were missing.

The higher values for blackjack in the reservoir stands depict a pattern of disturbance, particularly AR-3 where evidence of past fire, as old charred stumps, was found.

Trampling and grazing by livestock was reflected in all stands by a near absence of seedlings. The lack of larger post oaks indicate the heavy fuelwood demands on the forest prior to the 1930's, the greatest disturbance factor in the forest. Recovery since then has almost marked this former demand with a lack of 20 to 30 year-old stumps and fairly high density. However, the trees are small.

The first nine shrubs listed with coralberry and woodbine dominating are shown with their values for the climax. The remaining eight shrubs are mesic. There has been an almost complete destruction (by grazing pressure) of this layer in the reservoir sites.

Herbaceous structure is non-existent in the reservoir sites. Lespedeza repens and Opuntia macrorhiza are nonpalatable and have some presence. Even so, lateral continuity in this layer is poor in the climax. In areas where the synfolium is opened, old field species predominate and were not shown here as this vegetational type with some lateral integrity is the common vegetation in the study area and will be so shown next.

The Aristida - Dactylon Association appeared rapidly if the forest canopy was opened by lightning or lodging. Climax grasses, as little bluestem, from the nearby prairies occupied the area soon followed by climax forest seedlings. With the advent of settlers onto the Woodbine, this pattern changed. Little bluestem is a palatable grass and disappears with light grazing resulting in the unpalatable species forming the community, reaching a disclimax as the pressure continues.

The disclimax is reflected in the presence list of some eight stands from the west, central and eastern sections of the study area. These stands represent three subtypes of old field vegetation, namely: Ambrosia-dominated on silt; Aristida-dominated on sand or an intermediate admixture on intermediate texture; and Dactylon-controlled, a modified Ambrosia-Aristida subtype established by sprigging with coastal Bermuda (Table 20).

Ragweed is the dominant in the lowland sites as indicated by its high densities (74, 94, and 53 per centare) and frequency distributions of 86 to 100%. Combined values were fairly high for purple three-awn and the plantagos, but there are no clear cut co-dominants. Note the common components between the more mesic lowland and more xeric upland (Arf stands) types with differences being mostly one of density-frequency ratio changes. On intermediately-textured soil and thus intermediate aeration and water-holding potentials, ragweed and purple three-awn co-dominate over the other species.

A discrete fidelity pattern is non-apparent when the three presence lists are compared. Edaphic factors apparently do not control presence. This is not surprising as most weeds have broad ecological amplitudes.

In the Dactylon type, competition with the mat-forming Bermuda is severe. On similar soil types, ragweed and three-awn densities and frequencies indicate their near exclusion. Two exclusives occur in this type, namely burr clover and rescue brome.

The edaphic factors make the Eastern Cross Timbers unique in this area of Texas with respect to botanical elements. In a region of midgrass prairie, this narrow band of trees which exists on the sandy substrate derived from Woodbine sandstone has been ravaged by man. Preservation of a certain amount of this unique vegetation for posterity seems to be important. Most of the 35,050 acres included in the Aubrey Reservoir site could support Post Oak or Streamside Forests. Man's impact has reduced the actual forests to less than 5,000 acres. The best possible situation, ecologically, would be to let the entire site return to forests. However, even if the reservoir is not constructed, demographic, economic, etc., factors will preclude the area's return to climax vegetation. Essentially the reservoir represents an exchange of the present disclimaxes for an aquatic one.

Although the impact of the reservoir on natural terrestrial vegetation will be negative, establishment of areas around the reservoir which are restricted from use (e.g., grazing, indiscriminant cutting, vehicle traffic) will permit restoration and preservation of some of the unique climax forests of this area and make them available to more people.

Table 14. The species of trees found in the quadrats listed according to their relative importance and showing their distribution in the size classes.*

| Species | Reprod* | 1.5- | 3.0- | 6.0- | 9.0- | 12.0- | 15"+ |
|----------------------------|---------|-------------|------|------|-------|-------|------|
| | | 3.0" DBH | 6.0" | 9.0" | 12.0" | 15.0" | |
| <u>Celtis laevigata</u> | 492 | 16 | 27 | 13 | 3 | 3 | 6 |
| <u>Fraxinus pennsyl-</u> | | | | | | | |
| <u>vanica</u> var | | | | | | | |
| <u>lanceolata</u> | 324 | 1 | 4 | 4 | 4 | 1 | |
| <u>Celtis reticulata</u> | 603 | 15 | 8 | 2 | | | |
| <u>Ulmus crassifolia</u> | 68 | | | 4 | 8 | 6 | 8 |
| <u>Sapindus drummondii</u> | 154 | 1 | 5 | 4 | | | |
| <u>Bumelia lanuginosa</u> | 33 | 1 | 1 | 1 | | | |
| <u>Gleditsia trian-</u> | | | | | | | |
| <u>canthos</u> | 32 | 2 | | | | | |
| <u>Quercus macrocarpa</u> | 4 | | | | | 1 | 1 |
| <u>Quercus shumardii</u> | | | | | 2 | | 1 |
| <u>Sophora affinis</u> | 110 | 3 | 1 | | | | |
| <u>Crataegus viridis</u> | 5 | 3 | 1 | | | | |
| <u>Morus rubra</u> | 13 | 1 | | | | | |
| <u>Ulmus americana</u> | 2 | 2 | | | | | |
| <u>Maclura pomifera</u> | 2 | | | | | | |
| <u>Cercis canadensis</u> | 6 | | | | | | |
| <u>Acer negundo</u> | 1 | 1 | | | | | |
| <u>Carya illinoensis</u> | 1 | | | | | | |
| <u>Ulmus alata</u> | 9 | | | | | | |
| <u>Ulmus rubra</u> | 1 | | | | | | |

*Reprod. = under 1.5" diameter breast high; 1.5 - 3" etc. = size classes or trunk diameters at breast height

Table 15. The species of trees found in the line transect method showing their distribution in the size classes.*

| Species | Reprod. | 1.5- 3.0" | 3.0- 6.0" | 6.0- 9.0" | 9.0- 12.0" | 12- 15" | 15+" |
|------------------------------------|---------|--------------|--------------|--------------|---------------|------------|------|
| <u>Celtis laevigata</u> | 42 | 14 | 29 | 16 | 13 | 9 | 8 |
| <u>Ulmus crassifolia</u> | 17 | 1 | 4 | 10 | 10 | 11 | 10 |
| <u>Fraxinus pennsylvanica</u> var. | | | | | | | |
| <u>lanceolata</u> | 69 | 2 | 10 | 6 | 4 | | 4 |
| <u>Celtis reticulata</u> | 107 | 7 | 12 | 2 | 1 | 1 | |
| <u>Sapindus drummondii</u> | 47 | 4 | 10 | 1 | | | |
| <u>Quercus macrocarpa</u> | | | | 1 | 1 | | 3 |
| <u>Bumelia lanuginosa</u> | 3 | 1 | 1 | 2 | | 1 | |
| <u>Sophora affinis</u> | 44 | 1 | | | | | |
| <u>Morus rubra</u> | 2 | 2 | | | | | |
| <u>Gleditsia triacanthos</u> | 3 | | 2 | | | | |
| <u>Prunus mexicanus</u> | | | 2 | | | | |
| <u>Crataegus viridis</u> | 2 | 1 | 3 | | | | |
| <u>Cercis canadensis</u> | 1 | | 1 | | | | |
| <u>Ulmus rubra</u> | 1 | | | | | | |
| <u>Carya illinoensis</u> | | | | | | | 1 |

*Reprod. = under 1.5" diameter breast high; 1.5 - 3" etc. = size classes by trunk diameters in inches at breast height

Table 16. The species of trees found in the quadrats showing relative density, percent of density, frequency, basal areas in square inches, percent of basal area, and percent of abundance.

| Species | Density | | % Freq. | Basal Area | | % Abund. |
|------------------------------------|---------|---------|---------|------------|---------|----------|
| | Rel. | % Total | | Sq. In. | % Total | |
| <u>Celtis laevigata</u> | 25.5 | 27.6 | 86.4 | 2820 | 35.0 | 22.2 |
| <u>Fraxinus pennsylvanica</u> var. | | | | | | |
| <u>lanceolata</u> | 15.4 | 16.6 | 95.5 | 735 | 9.1 | 11.3 |
| <u>Celtis reticulata</u> | 28.6 | 30.9 | 72.7 | 276 | 3.4 | 31.0 |
| <u>Ulmus crassifolia</u> | 4.3 | 4.7 | 81.8 | 3146 | 39.1 | 4.6 |
| <u>Sapindus drummondii</u> | 7.5 | 8.1 | 68.2 | 260 | 3.2 | 8.1 |
| <u>Bumelia lanuginosa</u> | 1.6 | 1.8 | 36.4 | 64 | 0.8 | 1.3 |
| <u>Gleditsia triancanthos</u> | 1.6 | 1.7 | 50.0 | 8 | 0.1 | 1.1 |
| <u>Quercus macrocarpa</u> | 0.3 | 0.3 | 22.7 | 320 | 4.0 | 0.3 |
| <u>Quercus shumardii</u> | 0.1 | 0.2 | 9.1 | 351 | 4.4 | 0.2 |
| <u>Sophora affinis</u> | 5.1 | 5.6 | 31.8 | 28 | 0.4 | 5.6 |
| <u>Crataegus viridis</u> | 0.4 | 0.4 | 27.3 | 28 | 0.4 | 0.4 |
| <u>Morus rubra</u> | 0.6 | 0.7 | 27.3 | 4 | 0.1 | 0.7 |
| <u>Ulmus americana</u> | 0.2 | 0.2 | 4.6 | 8 | 0.1 | 4.6 |
| <u>Maclura pomifera</u> | 0.1 | 0.1 | 9.1 | 0 | 0.0 | 0.1 |
| <u>Cercis canadensis</u> | 0.3 | 0.3 | 9.1 | 0 | 0.0 | 0.3 |
| <u>Acer negundo</u> | 0.1 | 0.1 | 9.1 | 4 | 0.1 | 0.1 |
| <u>Carya illinoensis</u> | | | 4.6 | 0 | 0.0 | 0.1 |
| <u>Ulmus alata</u> | 0.4 | 0.4 | 13.6 | 0 | 0.0 | 0.4 |
| <u>Ulmus rubra</u> | 0.3 | 0.4 | 4.6 | 0 | 0.0 | 0.1 |

Table 17. The species of trees found in the line transect method showing their relative density, percent density, frequency, coverage in meters, percent coverage, and percent of abundance.

| Species | Density | | Freq. | Coverage | | Abund. |
|------------------------------------|---------|---------|-------|----------|---------|--------|
| | Rel. | % Total | | Meters | % Total | |
| <u>Celtis laevigata</u> | 5.9 | 23.0 | 95.5 | 310.6 | 35.9 | 23.0 |
| <u>Ulmus crassifolia</u> | 2.8 | 10.9 | 81.8 | 163.0 | 18.8 | 11.0 |
| <u>Fraxinus pennsylvanica</u> var. | | | | | | |
| <u>lanceolata</u> | 4.4 | 17.1 | 86.4 | 119.9 | 13.9 | 17.1 |
| <u>Celtis reticulata</u> | 5.9 | 23.0 | 81.8 | 88.8 | 10.3 | 23.0 |
| <u>Sapindus drummondii</u> | 2.6 | 11.5 | 68.2 | 46.8 | 5.4 | 11.5 |
| <u>Quercus macrocarpa</u> | 0.2 | 0.9 | 22.7 | 45.2 | 5.2 | 0.9 |
| <u>Bumelia lanuginosa</u> | 0.4 | 1.4 | 27.3 | 21.3 | 2.5 | 1.4 |
| <u>Sophora affinis</u> | 2.1 | 8.1 | 45.5 | 18.2 | 2.1 | 8.1 |
| <u>Morus rubra</u> | 0.2 | 0.9 | 18.2 | 12.5 | 1.4 | 0.9 |
| <u>Gleditsia triacanthos</u> | 0.2 | 0.9 | 18.2 | 9.6 | 1.1 | 0.9 |
| <u>Prunus mexicanus</u> | 0.1 | 0.3 | 9.1 | 6.9 | 0.8 | 0.4 |
| <u>Crataegus viridis</u> | 0.3 | 1.0 | 13.6 | 7.2 | 0.8 | 1.1 |
| <u>Cercis canadensis</u> | 0.1 | 0.3 | 9.1 | 4.4 | 0.5 | 0.4 |
| <u>Ulmus rubra</u> | 0.1 | 0.3 | 4.6 | 3.2 | 0.4 | 0.4 |
| <u>Carya illinoensis</u> | | 0.2 | 4.6 | 7.5 | 0.9 | 0.2 |

Table 18. Pooled arborescent presence and size class*
distribution for the Aubrey Reservoir Site #1.

| Species | Fr. | Reprod. | 1.5- 3.0" | 3.0- 6.0" | 6.0- 9.0" | 9.0- 12.0" | 12- 15" | 15+" |
|-------------------------------|-----|---------|--------------|--------------|--------------|---------------|------------|------|
| <u>Celtis laevigata</u> | 85 | 488 | 100 | 51 | 44 | -- | -- | 1 |
| <u>Fraxinus pennsylvanica</u> | 10 | 46 | 6 | 4 | -- | -- | -- | -- |
| <u>Ulmus crassifolia</u> | 100 | 252 | 12 | 3 | 2 | 1 | -- | -- |
| <u>Sapindus drummondii</u> | 12 | 41 | 2 | -- | -- | -- | -- | -- |
| <u>Bumelia lanuginosa</u> | + | 10 | 3 | -- | -- | -- | -- | -- |
| <u>Gleditsia tricanthos</u> | 15 | 24 | -- | 2 | -- | -- | -- | -- |
| <u>Quercus macrocarpa</u> | + | 6 | -- | -- | -- | -- | -- | 2 |
| <u>Quercus shumardii</u> | 20 | 14 | 3 | 2 | 2 | -- | -- | 1 |
| <u>Carya illinoensis</u> | 60 | 8 | -- | -- | -- | 12 | 22 | 1 |
| <u>Sophora affinis</u> | + | -- | 2 | -- | -- | -- | -- | -- |
| <u>Crataegus viridis</u> | 10 | 38 | 9 | -- | -- | -- | -- | -- |
| <u>Morus rubra</u> | + | 9 | 6 | -- | -- | -- | -- | -- |
| <u>Ulmus americana</u> | 20 | 150 | 54 | 1 | -- | -- | -- | 1 |
| <u>Maclura pomifera</u> | -- | -- | -- | -- | -- | -- | -- | -- |
| <u>Cercis canadensis</u> | + | 1 | -- | 2 | -- | -- | -- | -- |
| <u>Acer negundo</u> | + | -- | -- | 1 | -- | -- | -- | -- |
| <u>Cornus stolonifera</u> | 30 | 21 | 4 | -- | -- | -- | -- | -- |
| <u>Ilex decidua</u> | + | 2 | 3 | -- | -- | -- | -- | -- |
| <u>Ulmus alata</u> | + | -- | 2 | -- | -- | -- | -- | -- |
| <u>Salix nigra</u> | -- | -- | -- | -- | -- | -- | -- | -- |
| <u>Populus deltoides</u> | + | -- | -- | -- | -- | -- | 1 | -- |
| <u>Platanus occidentalis</u> | -- | -- | -- | -- | -- | -- | -- | -- |
| <u>Viburnum rifidulum</u> | -- | -- | -- | -- | -- | -- | -- | -- |

*Fr = frequency; Reprod. = under 1.5" DBH; 1.5 - 3", etc. = diameter size classes.

Table 19. Comparative densities and frequencies of upland post oak stands.
 PR = Cross Timbers presence rating; NC = near climax stand; AR =
 Aubrey Reservoir; d = density and f = frequency; x = present.

| Arborescent Species | PR | NC | | AR1 | | AR2 | | AR3 | | AR4 | | AR5 | |
|-----------------------------|----|-----|----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|
| | | d | f | d | f | d | f | d | f | d | f | d | f |
| <u>Quercus stellata</u> | 5 | 9.0 | 94 | 17 | 100 | 9 | 100 | 8.8 | 100 | 10 | 100 | 13 | 100 |
| <u>Quercus marylandria</u> | 5 | 0.3 | 30 | 3.5 | 82 | 4.4 | 60 | 19.0 | 100 | 1.2 | 70 | 3.6 | 50 |
| <u>Ulmus alata</u> | 4 | 4.5 | 41 | 3 | 82 | 2.3 | 60 | 4.7 | 100 | 18 | 94 | | |
| <u>Carya texana</u> | 4 | 0.4 | 12 | X | | | | 0.1 | 12 | | | | |
| <u>Juniperus</u> | | | | | | | | | | | | | |
| <u>virginiana</u> | 3 | 0.5 | 6 | | | | | | | 0.1 | 6 | | |
| <u>Ulmus cranifolia</u> | 3 | X | | | | 1.1 | 37 | | | 0.1 | 6 | | |
| <u>Cercis canadensis</u> | 3 | 1.1 | 18 | | | | | | | | | | |
| <u>Quercus shumardii</u> | 2 | X | | | | | | | | | | | |
| <u>Morus rubra</u> | 2 | X | | X | | | | | | | | | |
| <u>Carya illinoensis</u> | 1 | 5.0 | 6 | | | | | | | | | | |
| <u>Celtis laevigata</u> | 1 | 0.1 | 12 | | | | | | | | | | |
| <u>Maclura ponifera</u> | 1 | 0.1 | 6 | | | | | | | | | | |
| <u>Gleditsia tricanthos</u> | 1 | X | | | | | | | | | | | |
| Frutescent Species | | | | | | | | | | | | | |
| <u>Symphoricarpos</u> | | | | | | | | | | | | | |
| <u>orbiculatus</u> | 5 | 22 | 65 | 1 | 53 | 0.8 | 12 | X | | 3.6 | 9 | 0.2 | 17 |
| <u>Parthenocersus</u> | | | | | | | | | | | | | |
| <u>quinquefolia</u> | 5 | 18 | 71 | X | | | | X | | 0.4 | 12 | 0.8 | 12 |
| <u>Smilax bona-nox</u> | 5 | 4 | 35 | X | | | | X | | 1.1 | 35 | 0.9 | 23 |
| <u>Cocculus</u> | | | | | | | | | | | | | |
| <u>carolinensis</u> | 5 | 0.2 | 6 | X | | 0.5 | 12 | X | | 0.4 | 6 | 0.5 | 12 |
| <u>Rhus glabra</u> | 5 | 0.5 | 18 | X | | | | X | | 0.6 | 17 | 0.4 | 17 |

Table 19 (continued).

| Frutescent Species | PR | NC | | AR1 | | AR2 | | AR3 | | AR4 | | AR5 | |
|----------------------------|----|-----|----|-----|----|-----|----|-----|---|-----|---|-----|---|
| | | d | f | d | f | d | f | d | f | d | f | d | f |
| <u>Crataegus uniflora</u> | 4 | 0.2 | 12 | X | | 0.3 | 29 | X | | | | X | |
| <u>Bumelia lanuginosa</u> | 4 | 0.8 | 41 | 0.5 | 35 | 0.4 | 12 | | | | | X | |
| <u>Rhus toxicodendron</u> | 4 | 11 | 30 | 1.7 | 17 | | | | | | | | |
| <u>Rubus trivialis</u> | 4 | 0.4 | 12 | X | | | | X | | | | X | |
| <u>Vitis mustangensis</u> | 3 | 1.5 | 35 | | | | | | | | | | |
| <u>Cornus drummondii</u> | 3 | 1.0 | 12 | X | | | | | | | | | |
| <u>Viburnum rufidulum</u> | 3 | 0.3 | 18 | X | | | | | | | | | |
| <u>Rosa foliosa</u> | 2 | 0.4 | 6 | | | | | | | | | | |
| <u>Rhuscopallina</u> | 3 | X | | X | | | | | | | | | |
| <u>Prunus mexicana</u> | 3 | X | | | | | | | | | | | |
| <u>Rhus aromatica</u> | 2 | X | | | | | | | | | | | |
| <u>Xanthoxylum clava-</u> | | | | | | | | | | | | | |
| <u>herculis</u> | 1 | X | | | | | | | | | | | |
| <u>Cissus incisa</u> | 1 | X | | | | | | | | | | | |
| Herbescient Species | | | | | | | | | | | | | |
| <u>Panicum</u> | | | | | | | | | | | | | |
| <u>oligosanthes</u> | 5 | | | | | | | | | | | | |
| <u>Galium aparine</u> | | | | | | | | | | | | | |
| <u>Tredius flavus</u> | 5 | | | | | | | | | | | | |
| <u>Lespedeza repens</u> | 5 | | | | | | | | | | | | |
| <u>Ascyrum hypercoides</u> | 3 | | | | | | | | | | | | |
| <u>Opuntia macrorhiza</u> | 4 | | | | | | | | | | | | |
| <u>Panicum</u> | | | | | | | | | | | | | |
| <u>sphaerocarpon</u> | 4 | | | | | | | | | | | | |
| <u>Lespedeza virginica</u> | 4 | | | | | | | | | | | | |

Table 19 (continued).

| Herbescient Species | PR | NC | | AR1 | | AR2 | | AR3 | | AR4 | | AR5 | |
|-----------------------------|----|----|---|-----|---|-----|---|-----|---|-----|---|-----|---|
| | | d | f | d | f | d | f | d | f | d | f | d | f |
| <u>Sporobolus asper</u> | 3 | | | | | | | | | | | | |
| <u>Eragrostis lugens</u> | 5 | | | | | | | | | | | | |
| <u>Cyperus ovularis</u> | 4 | | | | | | | | | | | | |
| <u>Carex cephalophora</u> | 4 | | | | | | | | | | | | |
| <u>Carex physorhyncha</u> | 3 | | | | | | | | | | | | |
| <u>Sabatia campestris</u> | 3 | | | | | | | | | | | | |
| <u>Solidago radula</u> | 4 | | | | | | | | | | | | |
| <u>Aristida virgata</u> | 3 | | | | | | | | | | | | |
| <u>Collensia violacea</u> | 3 | | | | | | | | | | | | |
| <u>Mublenbergia</u> | | | | | | | | | | | | | |
| <u>capillaris</u> | 3 | | | | | | | | | | | | |
| <u>Eragrostis hirsuta</u> | 3 | | | | | | | | | | | | |
| <u>Gymnopogon ambiguus</u> | 3 | | | | | | | | | | | | |
| <u>Rhynchosia labifolia</u> | 3 | | | | | | | | | | | | |
| <u>Penstemon laxiflorus</u> | 3 | | | | | | | | | | | | |

AR1 and 2 = Elm Fork stands; AR3 = central stand; AR4 and 5 = Isle du Bois stands.

NB: 42 species with a PR of 2 or less are not shown.

Table 20.* Presence and quantitation of the three subtypes of old field vegetation in Aubrey Reservoir Site #1. D = density per centare and F = frequency.

| SPECIES | Amf-1 | | Amf-2 | | Amf-3 | | Arf-1 | |
|---|-------|-----|-------|-----|-------|----|-------|-----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Ambrosia artemisiifolia</u> | 74 | 100 | 94 | 100 | 53 | 86 | 14.3 | 86 |
| <u>Aristida purpurescens</u> | 2.4 | 30 | 46 | 80 | 11.4 | 28 | 62 | 70 |
| <u>Panicum oligosanthos</u> | 21 | 100 | 17 | 100 | | | 10.9 | 57 |
| <u>Plantago aristata</u> | 30 | 100 | 88 | 100 | | | 30.4 | 57 |
| <u>Carex sp.</u> | 19 | 100 | | | | | 1.7 | 28 |
| <u>Cnidocolus texana</u> | 0.7 | 60 | | | | | | |
| <u>Oenothera spachiana</u> | 1.2 | 40 | | | | | 2.1 | 28 |
| <u>Rumex hastatulus</u> | 0.1 | 10 | 4 | 50 | | | 1.1 | 57 |
| <u>Castilleja indusa</u> | 0.2 | 20 | 4 | 50 | | | 1.0 | 14 |
| <u>Oxalis stricta</u> | 0.3 | 30 | | | 9.7 | 57 | | |
| <u>Verbena halei</u> | 0.7 | 30 | 3 | 80 | | | 4.9 | 100 |
| <u>Achillia millefolium</u> | 2.8 | 20 | | | | | | |
| <u>Smilax Bona-nox</u> | 0.2 | 20 | 0.1 | 17 | | | 0.1 | 14 |
| <u>Gaillardia pulchella</u> | 0.1 | 10 | | | 0.6 | 14 | | |
| <u>Vicia sp.</u> | 0.5 | 20 | | | | | | |
| <u>Lepidium austrinum</u> | 0.9 | 39 | | | 0.7 | 43 | | |
| <u>Medicago polymorpha</u> var. <u>vulgaris</u> | 0.3 | 10 | 3 | 17 | | | 9.6 | 70 |
| <u>Euax verna</u> | 1.2 | 10 | | | 3.4 | 28 | 4.3 | 28 |
| <u>Asclepias viridiflora</u> | 0.1 | 10 | 0.1 | 14 | 0.1 | 14 | 0.1 | 14 |
| <u>Linaria texana</u> | 0.7 | 40 | | | | | | |
| <u>Onosmodium bejorensense</u> | 0.1 | 10 | | | | | 0.1 | 14 |
| <u>Ulmus crassifolia</u> | 0.2 | 20 | | | | | | |
| <u>Prosopis glandulosa</u> | 0.1 | 10 | | | | | | |
| <u>Vulpia octoflora</u> | | | 1.5 | 17 | | | 1.4 | 57 |
| <u>Sabatia campestris</u> | | | 4 | 80 | | | 0.7 | 14 |
| <u>Triodanis biflora</u> | | | 2 | 50 | 5 | 70 | 3.7 | 70 |

Table 20 (continued)

| Species | Arf-2 | | Am-Ar F | | BerF-1 | | BerF-2 | |
|---|-------|-----|---------|-----|--------|----|--------|----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Ambrosia artemisiifolia</u> | 11.6 | 55 | 77.4 | 100 | 1.1 | 40 | | |
| <u>Aristida purpurescens</u> | 89 | 100 | 64 | 100 | | | 2.2 | 20 |
| <u>Panicum oligosanthes</u> | | | 38 | 100 | | | 3.5 | 40 |
| <u>Plantago aristata</u> | 11 | 65 | 0.6 | 14 | 3.2 | 60 | | |
| <u>Plantago patagonica</u> | | | 7.1 | 86 | 18 | 80 | 3 | 20 |
| <u>Carex sp.</u> | | | 3.5 | 86 | | | | |
| <u>Cnidocolus texana</u> | | | | | | | | |
| <u>Oenothera spachiana</u> | | | | | | | | |
| <u>Rumex hastatulus</u> | | | | | | | | |
| <u>Castilleja indusa</u> | 12 | 88 | 0.1 | 14 | | | | |
| <u>Oxalis stricta</u> | 1.8 | 77 | 57 | 28 | | | | |
| <u>Verbena halei</u> | | | | | 0.2 | 20 | | |
| <u>Achillia millefolium</u> | 2.2 | 22 | 12 | 100 | | | 0.2 | 10 |
| <u>Smilax Bona-nox</u> | | | | | | | | |
| <u>Gaillardia pulchella</u> | | | | | 0.2 | 20 | | |
| <u>Vicia sp.</u> | | | | | | | | |
| <u>Lepidum austrinum</u> | | | 6.5 | 57 | | | | |
| <u>Medicago polymorpha</u> var. <u>vulgaris</u> | | | | | | | | |
| <u>Euax verna</u> | 6.5 | 66 | | | 30 | 80 | | |
| <u>Asclepias viridiflora</u> | 0.1 | 11 | 0.4 | 43 | 0.4 | 20 | 0.1 | 10 |
| <u>Linaria texana</u> | | | 2 | 43 | | | | |
| <u>Onosmodium bejorens</u> | | | | | | | | |
| <u>Ulmus crassifolia</u> | | | | | | | | |
| <u>Prosopis glandulosa</u> | | | | | | | | |
| <u>Vulpia octoflora</u> | | | | | | | | |
| <u>Sabatia campestris</u> | 22.6 | 77 | | | | | | |
| <u>Triodanis biflora</u> | 2.1 | 33 | 1.1 | 43 | 2 | 60 | 5.1 | 60 |

Table 20 (continued).

| Species | Amf-1 | | Amf-2 | | Amf-3 | | Arf-1 | |
|--------------------------------|-------|-----|-------|-----|-------|-----|-------|----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Composite</u> | 44 | 100 | | | | | 47.1 | 70 |
| <u>Hordeum pusillum</u> | 9 | 50 | | | 1.7 | 14 | 8.6 | 14 |
| <u>Cyperus sp.</u> | 3 | 50 | | | 0.9 | 14 | 1.1 | 28 |
| <u>Juncus sp.</u> | 0.7 | 17 | | | | | | |
| <u>Monarda punctata</u> | 36 | 80 | | | 7 | 57 | 1.3 | 14 |
| <u>Erigeron philadelphicus</u> | 6 | 67 | | | 2.4 | 57 | 1.1 | 43 |
| <u>Bromus japonicus</u> | 57 | 67 | | | 23.6 | 100 | 55 | 70 |
| <u>Daucus pusillus</u> | 18 | 50 | | | 9 | 70 | 33 | 86 |
| <u>Solanum carolinense</u> | 0.7 | 33 | | | 0.1 | 14 | | |
| <u>Mirabilis sp.</u> | 0.2 | 17 | | | | | | |
| <u>Cuscuta sp.</u> | 0.1 | 17 | | | | | | |
| <u>Opuntia macrorhiza</u> | 0.1 | 17 | | | | | 0.3 | 14 |
| <u>Sapindus drummondii</u> | 0.02 | 4 | | | | | | |
| <u>Bumelia lanuginosa</u> | 0.1 | 17 | | | | | | |
| <u>Spermolepis inermis</u> | 0.1 | 17 | | | | | | |
| <u>Desmanthus leptolobus</u> | 0.1 | 17 | | | | | | |
| <u>Sonchus oleraceus</u> | | | 5.7 | 100 | | | 6.3 | 28 |
| <u>Lindheimera texana</u> | | | 6.6 | 70 | | | | |
| <u>Verbena bipinnatifida</u> | | | 0.4 | 14 | | | | |
| <u>Pyrropappus multicaulis</u> | | | 0.7 | 14 | | | | |
| <u>Cercium undulatum</u> | | | 0.6 | 14 | | | | |
| <u>Geranium carolinianum</u> | | | 0.6 | 14 | | | | |
| <u>Manisurus cylindrica</u> | | | 0.1 | 14 | | | 0.3 | 14 |
| <u>Bouteloua rigidiseta</u> | | | | | | | 0.3 | 14 |
| <u>Buchloe dactyloides</u> | | | | | | | 2.6 | 28 |
| <u>Juniperus virginiana</u> | | | | | | | 1.7 | 28 |
| <u>Gaillardia aestivalis</u> | | | | | | | 9.4 | 28 |
| | | | | | | | 0.2 | 14 |
| | | | | | | | 0.2 | 14 |

Table 20 (continued).

| Species | Arf-2 | | Am-Ar F | | BerF-1 | | BerF-2 | |
|--------------------------------|-------|----|---------|-----|--------|-----|--------|----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Composite</u> | | | | | | | | |
| <u>Hordeum pusillum</u> | | | 5.0 | 57 | 0.2 | 20 | 0.1 | 10 |
| <u>Cyperus</u> sp. | | | | | | | | |
| <u>Juncus</u> sp. | | | | | | | | |
| <u>Monarda punctata</u> | | | | | 5.1 | 40 | | |
| <u>Erigeron philadelphicus</u> | 0.7 | 44 | 5.3 | 100 | | | | |
| <u>Bromus japonicus</u> | 22.4 | 77 | 22.4 | 57 | 50 | 80 | 9 | 60 |
| <u>Daucus pusillus</u> | 26 | 77 | 1.4 | 28 | | | | |
| <u>Solanum carolinense</u> | | | | | | | | |
| <u>Mirabilis</u> sp. | | | | | | | | |
| <u>Cuscuta</u> sp. | | | | | | | | |
| <u>Opuntia macrorhiza</u> | | | 0.1 | 14 | | | | |
| <u>Sapindus drummondii</u> | | | | | | | | |
| <u>Bumelia lanuginosa</u> | | | | | | | | |
| <u>Spermolepis inermis</u> | 16.5 | 88 | | | 4.4 | 100 | | |
| <u>Desmanthus leptolobus</u> | 4 | 55 | | | | | | |
| <u>Sonchus oleraceus</u> | | | | | | | | |
| <u>Lindheimera texana</u> | | | | | | | | |
| <u>Verbena bipinnatifida</u> | | | | | | | | |
| <u>Pyrropappus multicaulis</u> | 0.3 | 11 | | | | | | |
| <u>Cercium undulatum</u> | 2 | 55 | 0.3 | 14 | | | | |
| <u>Geranium carolinianum</u> | | | | | | | | |
| <u>Manisurus cylindrica</u> | | | | | 0.2 | 20 | | |
| <u>Bouteloua rigidiseta</u> | | | | | | | | |
| <u>Buchloe dactyloides</u> | | | | | | | | |
| <u>Juniperus virginiana</u> | | | | | | | | |
| <u>Gaillardia aestivalis</u> | 7.3 | 11 | 6.6 | 70 | | | | |

Table 20 (continued).

| Species | Amf-1 | | Amf-2 | | Amf-3 | | Arf-1 | |
|--------------------------------------|-------|----|-------|----|-------|----|-------|----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Linum</u> sp. | | | | | | | | |
| <u>Neptunia</u> <u>lutea</u> | | | | | | | | |
| <u>Sisyrinchium</u> <u>campestre</u> | | | | | | | | |
| <u>Krameria</u> <u>lanceolata</u> | | | | | | | | |
| <u>Vernonia</u> <u>Baldwinii</u> | | | | | | | | |
| <u>Baptisia</u> <u>spherocarpa</u> | | | | | | | | |
| <u>Cynodon</u> <u>dactylon</u> | | | | | | | | |
| <u>Medicago</u> <u>orbicularis</u> | | | | | | | | |
| <u>Bromus</u> <u>cartharticus</u> | | | | | | | | |

Table 20 (continued).

| Species | Arf-2 | | Am-Ar F | | BerF-1 | | BerF-2 | |
|-------------------------------|-------|----|---------|----|--------|-----|--------|-----|
| | D | F% | D | F% | D | F% | D | F% |
| <u>Linum sp.</u> | 19.6 | 88 | 3.0 | 86 | | | | |
| <u>Neptunia lutea</u> | | | 0.7 | 43 | | | | |
| <u>Sisyrinchium campestre</u> | | | 0.9 | 57 | | | | |
| <u>Krameria lanceolata</u> | | | 0.3 | 14 | | | | |
| <u>Vernonia Baldwinii</u> | | | 0.3 | 14 | | | | |
| <u>Baptisia spherocarpa</u> | | | 0.6 | 14 | | | | |
| <u>Cynodon dactylon</u> | | | | | 59 | 100 | 86 | 100 |
| <u>Medicago orbicularis</u> | | | | | 5.6 | 100 | | |
| <u>Bromus cartharticus</u> | | | | | 2.1 | 20 | | |

* Amf-1; Amf-2; Amf-3 = Ambrosia old field #1, #2, #3, respectively

Arf-1; Arf-2 = Aristada old field #1 and #2, respectively

Am-Arf = Ambrosia-Aristada old field

BerF-1; BerF-2 = Bermuda old field #1 and #2, respectively

Zoological Elements

Aquatic Invertebrates

Aquatic macrobenthos play an important and integral role in the ecology and economy of both lotic and lentic systems. It is therefore desirable to assess the effects of impoundment on aquatic macrobenthos.

No detailed pre- and post-impoundment macrobenthos community analyses have been reported from drainage systems of the southwestern United States; however, unpublished post-impoundment data are available for the modified Brazos River, below Possum Kingdom Dam, Texas, as a result of a 1970-72 study by the Aquatic Entomology Research Team of the North Texas Institute for Environmental Studies. Appropriate information from that study are included in this report for comparison purposes.

Most studies of the biological effects of impoundments on rivers have dealt with downstream changes in plankton originating from the reservoir (35). Two recent studies, one in Wisconsin (36) and the other in Ontario, Canada (35), have dealt with a broader spectrum of macroinvertebrates and plankton. In both studies, pronounced differences were noted in composition and densities between upstream (or pre-impoundment) communities, and those downstream. In both studies, water release was from the hypolimnion, significantly altering temperature, nutrients and turbidity.

Spence and Hynes (35) noted downstream increases in the numbers of Baetis and Caenis (Ephemeroptera), Chironomidae, Simuliidae (Diptera), Optiservus (Coleoptera), Hydropsychidae and Hyaella over upstream samples. Only the Plecoptera and the mayfly Stenonema were considerably reduced.

Hilsenhoff (36) noted at least a short term reduction in the pre-post-impoundment number of species 600 feet below a dam on Mill Creek in Wisconsin. However, the last samples, taken 2 years after impoundment, may have allowed insufficient time for recovery from construction effects and an apparent 6 month flow disruption from impoundment to initiation of hypolimnion drain function. The previously dominant families Beatidae, Hydropsychidae and Elmidae were replaced mostly by

Simuliidae, Gammarus and Chironomidae. Changes in a riffle 2 miles downstream were similar, but not as pronounced.

It appears from these and other work that immediate impoundment effects on downstream lotic communities are variable, depending on geography, substrate and physical and chemical water characteristics. However, our preliminary examination of data from the nearby modified Brazos River, previously mentioned, indicates that longer term effects are probably highly favorable, and manifested in succession toward a higher species diversity and greater production, due to the stabilizing effect of less drastic temperature, nutrient and other changes.

A horizontal stratification, heretofore little documented, probably results over a period of time, with a highly modified system of altered species composition existing immediately below dams, a highly diverse, productive system existing in a zone yet to be horizontally defined farther downstream, then gradual return to characteristically "upstream" communities. The latter is due to the increasing influence of edaphic, terrestrial and climatic factors in the area.

The following sampling stations were used to study pre-impoundment spring aquatic macrobenthos communities on and adjacent to the proposed Aubrey Reservoir site:

- I - Upstream station located on the Elm Fork Trinity, just below the FM 51 Bridge in the west city limits of Gainesville, Texas.
- II, III - On site (inundation) stations, located below Elm Fork Bridge and above Isle du Bois Creek, respectively, on FM 455.
- IV, V - Downstream stations, located above the old Green Valley Bridge ca. 2 miles downstream and above the FM 428 Bridge ca. 4.5 miles downstream, respectively.

Two quantitative samples/station were taken in riffle areas with a modified Hess Sampler, on 30 March and 4 May 1972. In addition, a qualitative sample was taken with a Turtox Aquatic Net along the stream margins. Dragonflies, damselflies and shore invertebrates in the area were captured and added to the qualitative sample. Samples, preserved in 60% isopropanol, were hand picked, sorted, identified and counted in the laboratory.

Dominant riffle benthos in the Elm Fork of the Trinity River near the proposed Aubrey Reservoir site are Centropetilius, Heptagenia, Thraulodes, Cheumatopsyche, Stenelmis, Simulium, and Polypedilum (Table 21). Except for Centropetilius these same organisms are dominant in the nearly modified Brazos River, where spring standing crops are higher. Brazos River dominant species that were conspicuously absent in the Trinity samples were Tricorythodes, Hydropsyche and Neoperla.

From the standpoint of species diversity, mean S/1000 N was 19 in the Trinity and 23 in the Brazos. Species diversity alone, however, is not considered by the investigator as a true indication of the maturity of potential of the Elm Fork Trinity River. Impoundment should eventually result in a horizontal stratification in the ca. 10 miles of stream, similar to that below Possum Kingdom Dam in the Brazos and that reported by Spence and Hynes (35).

Benthos diversity and production should be materially increased in a zone beyond ca. 2 miles below the proposed dam. Invertebrate species diversity and production should change little upstream and on site, with a "trade-off" in actual species composition on site, from lotic to lentic species. The ca. 2 mile stretch of river immediately below the dam should also experience a trade-off or possible reduction in species composition due to altered stream temperatures, and decreased production due to a scouring effect during periods of high rainfall.

These predictions only apply if a constant minimal flow of an approximate range of 10-30 cfs is maintained through discharge from gates, or a hypolimnion drain. For creation of a positive EIU in the river and enhancement of its potential for sports fisheries, canoeing and other recreational activity, a constant discharge within the above minimal range is thereby recommended. This range was arrived at by examining discharge rates at the Dark Valley gaging station on the Brazos River near Palo Pinto, Texas, where our benthos studies have shown high production.

Other aquatic invertebrates found in the Elm Fork Trinity River, and Standing Crops are shown in Table 21 below. In addition, organisms found only in qualitative samples included: Hexagenia (Ephemeroptera); Helodidae, Tropisternus and Hydroporus (Coleoptera); Hetaerina, Ischnura, Macromia and Nasiaeschna (Odonata); Rheumatobates, Gerris, Microvelia and Gelastocoris (Hemiptera); Palaemonetes and Orconectes

(Crustacea), and Tritogonia (Mollusca).

Terrestrial Invertebrates

Student insect collections taken at different seasons from the area over the past 5 years were examined. Of the approximate 300 families, no endemic or endangered species are present. Consideration of terrestrial invertebrate populations have been incorporated in appropriate parameter reports. Due to the general distribution, vagility and natality of terrestrial insects, no significant area effect other than displacement from the immediate reservoir basin (35,050 acres of upper guide contour) on populations will be manifested as result of construction of the proposed Aubrey Reservoir.

Table 21. Aquatic invertebrates of the proposed Aubrey Reservoir vicinity, March-May, 1972.

| Organism | Stations I | Mean Density/M ² | | | | | All |
|----------------------|------------|-----------------------------|-----|-----|-----|-----|-----|
| | | II | III | IV | V | | |
| Turbellaria | | | | | | | |
| <u>Dugesia</u> | 0 | 0 | 0 | 3 | 0 | 1 | |
| Oligochaeta | | | | | | | |
| Unidentified | 14 | 3 | 6 | 27 | 3 | 11 | |
| <u>Branchiura</u> | 0 | 5 | 0 | 33 | 16 | 11 | |
| Hirudinea | | | | | | | |
| <u>Glossiphonia</u> | 46 | 0 | 0 | 3 | 0 | 10 | |
| Ephemeroptera | | | | | | | |
| <u>Stenonema</u> | 6 | 0 | 0 | 0 | 6 | 2 | |
| <u>Heptagenia</u> | 134 | 124 | 3 | 92 | 148 | 100 | |
| <u>Isonychia</u> | 3 | 27 | 0 | 94 | 3 | 25 | |
| <u>Thraulodes</u> | 60 | 530 | 8 | 520 | 374 | 298 | |
| <u>Ephemerella</u> | 3 | 0 | 11 | 0 | 0 | 3 | |
| <u>Caenis</u> | 21 | 3 | 0 | 0 | 11 | 7 | |
| <u>Centroptilium</u> | 597 | 84 | 6 | 111 | 0 | 160 | |
| Odonata | | | | | | | |
| <u>Ophiogomphus</u> | 0 | 8 | 0 | 0 | 3 | 2 | |
| <u>Erpetogomphus</u> | 0 | 11 | 0 | 0 | 0 | 2 | |
| <u>Gomphus</u> | 0 | 0 | 3 | 0 | 0 | 1 | |
| <u>Argia</u> | 8 | 0 | 0 | 0 | 0 | 2 | |

Table 21 (continued).

| Organism | Mean Density/M ² | | | | | |
|-------------------------|-----------------------------|------|------|-------|------|------|
| | Stations I | II | III | IV | V | All |
| Plecoptera | | | | | | |
| <u>Perlesta</u> | 113 | 30 | 35 | 27 | 14 | 44 |
| Hemiptera | | | | | | |
| <u>Trichocorixa</u> | 0 | 0 | 6 | 0 | 0 | 1 |
| <u>Rhagovelia</u> | 0 | 0 | 0 | 3 | 0 | 1 |
| Megaloptera | | | | | | |
| <u>Corydalis</u> | 0 | 5 | 0 | 0 | 0 | 1 |
| Trichoptera | | | | | | |
| <u>Chimarra</u> | 3 | 0 | 0 | 0 | 0 | 1 |
| <u>Cheumatopsyche</u> | 1474 | 3368 | 446 | 2096 | 2313 | 1939 |
| <u>Hydroptilia</u> | 0 | 0 | 0 | 8 | 0 | 2 |
| Coleoptera | | | | | | |
| <u>Agabinus</u> | 0 | 0 | 0 | 3 | 0 | 1 |
| <u>Dineutus</u> | 0 | 0 | 3 | 0 | 0 | 1 |
| <u>Berosus</u> | 3 | 0 | 0 | 0 | 0 | 1 |
| <u>Helichus</u> | 0 | 3 | 0 | 0 | 0 | 1 |
| <u>Stenelmis</u> | 199 | 594 | 8 | 317 | 135 | 251 |
| Diptera | | | | | | |
| <u>Simulium</u> | 102 | 2173 | 4384 | 6663 | 6 | 2666 |
| <u>Chironomus</u> | 0 | 0 | 3 | 0 | 0 | 1 |
| <u>Cryptochironomus</u> | 0 | 6 | 5 | 6 | 3 | 4 |
| <u>Polypedilum</u> | 221 | 382 | 146 | 759 | 132 | 328 |
| <u>Palpomyia</u> | 3 | 0 | 0 | 4 | 0 | 1 |
| <u>Tabanus</u> | 0 | 0 | 0 | 3 | 0 | 1 |
| <u>Dolichopodidae</u> | 0 | 0 | 3 | 0 | 0 | 1 |
| Mollusca | | | | | | |
| <u>Physa</u> | 3 | 0 | 0 | 0 | 0 | 1 |
| <u>Viviparus</u> | 0 | 0 | 0 | 0 | 6 | 1 |
| <u>Sphaerium</u> | 41 | 3 | 8 | 16 | 0 | 14 |
| Total | 3054 | 7359 | 5084 | 10788 | 3173 | 5897 |

Fishes

Introduction

One of the duties of the scientist is prediction of the effects of man's actions on the environment. The fishery scientist is usually charged with the responsibility for predicting the effects of human projects on fishery resources and at the same time suggesting management practices which will minimize harmful effects and maximize beneficial effects. In this section of our report we will discuss the current and potential fishery resources of the Aubrey Reservoir site and make recommendations for their successful management.

Inland fisheries resources in Texas are of greatest importance for their use in recreational or sport fishing. It is well recognized (37) that the sport fisherman's enjoyment of fishing is divided into five components: 1) the planning and contemplation of the fishing trip, which includes the purchasing, construction, or assembling of gear and the planning of transportation and lodging, 2) the travel from home to the fishing site with its attendant experiences, 3) the actual activity involved in fishing when the body of water is reached; this phase may include camping out at the water's edge, the act of fishing, cleaning of the catch, and contemplation of the natural scene, 4) the return trip to the home, perhaps via an alternate route to achieve new experiences at other parks or recreational sites, and 5) there is the very important recall aspect of the fishing experience. By recalling memories of the fishing experience and relating them to others, the fisherman enhances the experience and reaffirms its personal worth. The recall phase may be supported by the gathering of photographs of the experience, mounting the catch, or preservation of a part of the catch for future consumption. The Sport Fishing Institute has estimated that approximately 0.75 billion pounds of fish are captured from inland waters and consumed by anglers each year in the U.S. (37).

Commercial fishing in inland waters is of much less significance in Texas than recreational or sport fishing. Although a potential for commercial fisheries exists in most reservoirs

of the state, harvesting methods are of such low efficiency that these potentials are seldom developed to their greatest extent.

Methods and Materials

In assembling data on fishes and fisheries of the Aubrey Reservoir site we worked both in the field and in the laboratory. In the field we began making collections of fish on 13 February 1972 and thereafter devoted each weekend to the collection of fish and other field work.

Fish Collections

Fish were collected from each of the flowing tributaries to Elm Fork and Isle du Bois Creek within the reservoir site. These collections were made with one of three seines: 20' x 4' X 1/8" mesh, 20' X 4' X 1/4" mesh, or 10' X 4' X 1/8" mesh. Between 2 and 20 seine hauls of 20-100' in length were made in each stream. A few special collections were made with a hand dip net and by angling with hook and line. A total of 31 fish collections were made in streams with the seines, and they contained a total catch of 5,587 fish of 28 species.

The fish populations of six farm ponds in the area were sampled with the 20' X 4' X 1/4" seine and with a 75' X 6' X 3/4" mesh seine. A total of 202 fish of 10 species were included in the pond samples.

During the course of our field investigations, we made every effort to talk with fishermen on the streams and ponds and with land owners in the area. Our objectives in these interviews were: 1) to obtain a sampling of angler opinions on the quality of fishing and the expected effects of the new reservoir on fishing potential, 2) to determine the principal species of fish sought, and 3) to determine the harvest of fish from the area relative to similar waters in north Texas. The interviews were conducted on an informal basis and involved approximately 30 people.

Measurement of Stream and Pond Surfaces

In applying the Battelle EES it became necessary to determine the area of water surface already present in the reservoir site. We measured the width of each stream in the area at several locations and then averaged the measurements to obtain a mean width for each stream. All of the measurements were made in April during a time when the streams were high but not at flood stage. These mean widths were then multiplied by the total length of the stream in the area as measured on U.S. Geological Survey topographic maps. The area of stock tanks, ponds and reservoirs at the proposed site were also measured by employing a layover grid on the topographic maps. These maps were constructed in 1961 and probably underestimate new reservoirs constructed by less than 10%.

Literature Search

Finally, we made an extensive search of the literature on fishery resources (both sport and commercial) in the state of Texas and in the southern U.S. We made extensive use of the Job Progress Reports required by the Federal Aid in Fisheries Restoration Act and filed by fisheries biologists of the Texas Parks and Wildlife Department between 1960 and 1972. These reports contributed valuable data on fish populations, harvest rates, and angling intensities on other reservoirs and streams in Texas.

Results

Collections from the stream seining were divided into two portions, Elm Fork of the Trinity River and the smaller tributary streams. We made eleven seining collections from Elm Fork between the city of Gainesville and the confluence of Elm Fork and Clear Creek. A total of 1394 fish of 18 species were included in the collections. The two most abundant fish present were red shiners (Notropis lutrensis) and bullhead minnows (Pimephales vigilax; Table 22). The most important sport fish species present were channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis

olivaris), white bass (Morone chrysops), sunfish (several species of Lepomis), and largemouth bass (Micropterus salmoides). The most important commercial species present were carp (Cyprinus carpio), carpsuckers (Carpiodes carpio), and long-nose gar (Lepisosteus osseus).

In the smaller tributary streams of the reservoir site, we made 20 collections with a total of 2923 fish of 23 species. The most abundant species were shiners (several species of Notropis), mosquitofish (Gambusia affinis), and green sunfish (Lepomis cyanellus; Table 23). The most important sport fishes were channel catfish, sunfish, largemouth bass, spotted bass (Micropterus punctulatus), and white crappie (Pomoxis annularis). The commercial species present were black bullhead (Ictalurus melas), and spotted sucker (Minytrema melanops).

The fish species present in a farm pond are, of course, largely the result of stocking practices of the owner. Therefore, it is not surprising that the most abundant and/or significant species found in the ponds were sunfish, channel catfish, largemouth bass, white crappie, and golden shiner (Notemigonus crysoleucas), a popular bait minnow in this area (Table 24).

One of the reasons for making the fish collections was to enable us to predict what species of fish would be present in the proposed reservoir. Although each reservoir is a unique case, we anticipate that the future fish population of Aubrey Reservoir will be similar to those of other reservoirs in the area. Menn (12) and Bonn (11, 38) have reported gill net and seine catches from Garza-Little Elm Reservoir 11 miles to the south of the Aubrey site, Lake Bridgeport 48 miles west of the site, Grapevine Reservoir 25 miles southwest of the site, and Eagle Mountain Lake 40 miles southwest of the site. They found that the most important game fish in these reservoirs were: white bass, largemouth bass, white crappie, channel catfish, sunfish, and flathead catfish. The most abundant commercial species were: smallmouth buffalo (Ictiobus bubalus), river carpsucker, carp, shortnose gar (Lepisosteus oculatus), drum (Aplodinotus grunniens), and black bullhead. We anticipate that these same species will be of greatest importance in the proposed Aubrey Reservoir if normal stocking and management procedures are employed by the Texas Parks and Wildlife Department.

Interviews with Anglers and Pond Owners

Most of the fishermen interviewed were fishing in Elm Fork at the highway 455 bridge, just below the confluence of Elm Fork and Isle du Bois Creek, at the highway 428 bridge, or at the confluence of Elm Fork and Clear Creek. Early in the spring most fishermen fished at the downstream locations and used spinning outfits and artificial lures to catch white bass. The spawning run of white bass from Garza-Little Elm Reservoir up Elm Fork each spring constitutes a fairly significant sport fishery as far north as the highway 455 bridge (39).

Later in the spring, after the white bass run ended, fishermen fished for channel and flathead catfish between the highway 455 bridge and highway 428 bridge, and for white crappie from Garza-Little Elm Reservoir north to the highway 428 bridge. Most of the anglers seeking catfish used a casting or spinning outfit and one of the usual catfish baits: worms, blood, liver, entrails, and fish. Crappie fishermen used canepoles as well as rods and reels and employed minnows as bait.

It appeared that most of the catfish harvest was made by a small percentage of local individuals who used short trotlines or bank lines. Between the highway 455 bridge and the highway 428 bridge, we estimated that there was one bank line on each side of the stream every 50 yards. One fisherman using bank lines reported that he sometimes sold his excess catch of catfish to local markets in Sanger and Pilot Point.

The smaller tributary streams are not fished heavily, even in the spring months when they are full of water. Only one fisherman was interviewed at the highway 455 bridge over Isle du Bois Creek. He told us that he had caught a few crappie and catfish and one largemouth bass from Isle du Bois in the past three years, and that he only fished in Isle du Bois when his favorite spot on Elm Fork was already occupied by other fishermen.

Pond fishermen in the area are usually fishing for catfish, sunfish, largemouth bass, or crappie. Some of the larger ponds in the area have good reputations for producing several 4-12 pound catfish and a few 3-5 pound largemouth bass each year.

Both the stream and pond fisheries are conducted almost entirely by local rural residents and residents of Sanger, Green Valley, Aubrey, and Pilot Point. Very few Denton residents fish above the confluence of Clear Creek and Elm Fork. Only one resident of Dallas was interviewed. We might point out that access to most of the ponds and streams is only possible over private property, and this restricts the fishing to local inhabitants who have had the opportunity to become acquainted with the land owners. Most of the land owners interviewed said that they usually permitted fishing only by relatives and close friends and that strangers were denied access or asked to pay a small fee in order to fish.

Discussion

In general it appears that the fish fauna of the proposed Aubrey Reservoir site is typical of warmwater streams and farm ponds throughout northeast Texas. There are, as far as is known, no unique, rare, or endangered species of fish in the area. Nor are the fish habitats available unique or unusual for this part of the state.

The existing sport fisheries are rather small in terms of total harvest and are engaged in by local residents. The principal stream species sought throughout the year are channel and flathead catfish. A small fishery for white bass develops each February and March during the spawning season.

Construction of the reservoir would inundate approximately 70.8 acres of stream and 35.3 acres of pond surface, and replace it with approximately 25,300 acres of reservoir surface. As we have outlined in the commercial and sport fish section of the Battelle EES the expected reservoir fisheries will be much more extensive and valuable than the existing fisheries. While an eight-mile-long section of Elm Fork will be inundated and removed from the white bass fishery, this may be offset to some extent by the possible creation of new white bass runs up Elm Fork and Isle du Bois Creek from the new reservoir. The most heavily fished portion of the white bass spawning run is below the proposed dam site in the area of the confluence of Clear Creek and Elm Fork and will not be inundated.

Recommendations

The following recommendations are suggested as means of minimizing the adverse impacts of the project on the fishes of the area and of enhancing the fishery benefits to be derived from the project. Some of these recommendations will conflict with other proposed recommendations or uses of the reservoir. The resolution of these conflicts is the responsibility of the U.S. Army Corps of Engineers. However, we should point out that if the recommendations are not followed it might be necessary to alter some of the environmental impact statements and calculations. The calculated environmental impacts presuppose that the recommendations will be adhered to.

1. During construction of the dam, the turbidity of Elm Fork below the reservoir site is expected to increase and water levels are expected to fluctuate widely. These events will lead to a decline in the fish populations between the construction site and Garza-Little Elm Reservoir to the south. We recommend that the contractor be legally bound to use construction practices which will minimize these effects as much as possible. In particular, we recommend that turbidities be held below 600 to 800 JTU and that flows be maintained at a reasonable continuous level during the months of February-April when the spring run of white bass is in progress.

2. The stabilization of flows expected below the dam coupled with the expected general improvement in water quality will probably permit the establishment of a scenic river fishery. To protect this fishery, we recommend that a minimum flow be established of at least 15 cfs.

3. We recommend that every consideration be given to the possibility of providing for a variety of water release structures in the dam. If water can be released from low in the reservoir (hypolimnion drain) as well as at intermediate depths and at the surface (epilimnion drain), the fishery manager is provided with a powerful tool for managing the water quality (and hence the fish populations) of both the reservoir and the tailrace (40).

4. We recommend that during construction of the reservoir all trees, brush, fences, buildings, and machinery be removed from the middle portions of the reservoir. Such a clearing operation would reduce hazards to navigation and the operation of fishing gear. Complete removal of cut trees and brush would reduce unsightly floating materials

and retard the rate of eutrophication.

However, we also recommend that it would be best for the fish populations of the reservoir if the contours of the bottom of the reservoir were to be left in an undisturbed state. Gulleys, road cuts, stream cuts, and other broken features of the natural terrain provide habitat for many desirable species of fish and experienced fishermen are able to seek out and fish such areas with the aid of modern depth finders. Natural gravel-covered ridges and gravel roads should also be left intact on the floor of the reservoir as these often provide spawning sites for desirable sport fishes.

5. We recommend that on at least 5-10% of the area of the reservoir, at the margins, standing timber be left in position. Davis and Hughes (41) have demonstrated that catchable size largemouth bass and bluegills were more abundant in the tree areas of Bussey Lake, Louisiana, and that fishermen preferred to fish in the trees. Leaving a small percentage of the reservoir in standing timber creates two distinct habitats in the reservoir and the fishery manager can then establish two different kinds of fishing on a single body of water. For example, Davis and Hughes (41) found that the flier, a species of sunfish, and crappie provided an excellent open water fishery on Bussey Lake which complimented the bass and bluegill fisheries of the tree areas.

6. We recommend that during construction of the reservoir certain areas be cleared and permanently marked for the operation of fish sampling gear by the Texas Parks and Wildlife Department and other agencies and organizations involved in fishery research and management. Bonn (42) described the utility of such areas in Pat Mayse Reservoir near Paris, Texas. These areas should be cleared, grubbed, graded level, inspected by a fisheries biologist, and perhaps treated with an herbicide to retard secondary growth of woody plants before inundation. Trawl lanes should be 0.5 to 1.0 miles long by 200-300 yards wide and in water 8-12 feet deep. Gill nets sites should be 300-500 yards square and in water 10-20 feet deep. Beach seine sites should be 200-300 yards square, adjacent to shore, and located in an area where the beach slopes gently out to a depth of about 10 feet at 100 yards from shore. It is particularly important that no secondary growth of woody vegetation be permitted in the seining sites before impoundment and that the beach above the waterline be cleared for 30-50 feet to facilitate setting and pulling of the seine.

7. We recommend that every effort be made to stabilize water levels in the new reservoir, particularly during those months (March-May) when the more desirable species of fish are spawning in shallow water. At other times of the year unavoidable drawdowns should be made as gradually as possible to avoid the exposure of large expanses of unsightly and impassable mud flats.

8. We recommend that the U.S. Army Corps of Engineers construct at least 6-12 boat ramps at strategic locations around the reservoir. As many as possible of the ramps should be surrounded with adjacent picnic areas with tables, benches, grassed areas, trees, and restrooms. Such facilities will encourage maximum use and enjoyment of the sport fishery resources.

9. We recommend that the land contained by the upper guide contour but not normally flooded be seeded to suitable grasses and that the natural vegetation be preserved and encouraged wherever possible. If grazing must be permitted on the area, it should be restricted to less than one animal unit per 10 acres to prevent overgrazing and erosion of the immediate watershed.

10. We recommend that the Corps consult freely with the Texas Parks and Wildlife Department on the expected dates of filling of the reservoir. Such cooperation will enhance the planning of stocking programs of desirable fish species. It is expected that largemouth bass, channel catfish, sunfishes, and crappies will be stocked in the reservoir. The addition of one of the larger open-water sport fish (walleye or striped bass) should also be seriously considered for inclusion in the stocking program.

Table 22. Catch of fish from Elm Fork of the Trinity River in the proposed Aubrey Reservoir area, 10'-20' seines of 1/8"-1/4" mesh; February 19-May 19, 1972.

| Species | Location (river mile above confluence; dam=60.0 mi.) | | | | | | | | | |
|------------------------------|--|------|----|----|----|------|----|------|-------|------|
| | RM | RM | RM | RM | RM | RM | RM | RM | RM | RM |
| | 83.3 | 65.3 | 65 | 64 | 63 | 61.1 | 58 | 57.2 | 49.8 | |
| <u>Lepisosteus osseus</u> | 1 | | | 2 | | | | 2 | | 3 |
| <u>Dorosoma cepedianum</u> | | | | | | | | 4 | | |
| <u>Cyprinus carpio</u> | 2 | | | | | | | | | |
| <u>Notropis lutrensis</u> | 388 | 247 | 31 | 62 | 92 | 162 | 83 | 153 | 135 | |
| <u>Pimephales vigilax</u> | 2 | 1 | 1 | 1 | 1 | 12 | 1 | 11 | 5 | |
| <u>Carpodes carpio</u> | | | | | | 1 | | | | |
| <u>Menidia audens</u> | | | | | | | | | 18 | |
| <u>Ictalurus punctatus</u> | | | | | | 1 | 1 | | | |
| <u>Noturus gyrinus</u> | | | | | | | 2 | 7 | | |
| <u>Pylodictis olivaris</u> | | | | | | | | | | 1 |
| <u>Fundulus notatus</u> | 1 | | | | | | | | | |
| <u>Morone chrysops</u> | 1 | | | | | | | | | |
| <u>Lepomis cyanellus</u> | 1 | | | | | | | | | |
| <u>Lepomis gulosus</u> | 1 | | | | | | | | | |
| <u>Lepomis macrochirus</u> | 5 | | | | | | | | | |
| <u>Lepomis marginatus</u> | 2 | | | | | | | | | |
| <u>Lepomis megalotis</u> | | | | 1 | 1 | 1 | 1 | | | |
| <u>Micropterus salmoides</u> | | | | | | 1 | | | | |
| Number of Fish | 354 | 248 | 32 | 66 | 94 | 178 | 88 | 177 | 162 = | 1399 |
| Number of Collections | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 = | 11 |

Table 23. Catch of fish in smaller tributaries of the Aubrey Reservoir site. All collections made with a 20' or 10' long 1/4" or 1/8" mesh seine from February 19 to May 19, 1972.

| <u>Species</u> | <u>Location</u> | | | | | | |
|--------------------------------|---------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|---------------------|
| | Buck Cr. Hwy 377 | Ranee Cr. Hwy 377 | Spring Cr. Hwy 377 | Jordan Cr. Hwy 902 | Timber Cr. Hwy 902 | Indian Cr. Hwy 902 | Wolf Cr. Hwy 902 |
| <u>Dorosoma cepedianum</u> | 1 | | 4 | 21 | | 7 | |
| <u>Notemigonus crysoleucas</u> | | | 9 | | 28 | 33 | |
| <u>Notropis lutrensis</u> | | | | | 53 | 3 | |
| <u>Notropis shumardi</u> | | | | | 11 | 4 | |
| <u>Pimephales vigilax</u> | | | | | | 4 | |
| <u>Notropis venustus</u> | | | | | | | |
| <u>Minytrema melanops</u> | | | | | | | |
| <u>Menidia audens</u> | | | | | | | |
| <u>Ictalurus melas</u> | | 2 | | | | | |
| <u>Ictalurus punctatus</u> | | | | | | | |
| <u>Fundulus notatus</u> | | | | | | 41 | |
| <u>Gambusia affinis</u> | | | | | 14 | 384 | |
| <u>Lepomis cyanellus</u> | 3 | 15 | 4 | 11 | 7 | 5 | 2 |
| <u>Lepomis gulosus</u> | | | 2 | 1 | | | |
| <u>Lepomis humilis</u> | | 1 | | 4 | | 2 | |
| <u>Lepomis macrochirus</u> | 3 | 5 | 12 | 13 | | 6 | |
| <u>Lepomis marginatus</u> | | 1 | | | | 1 | |
| <u>Lepomis megalotis</u> | | | | | | | |
| <u>Micropterus salmoides</u> | | | | | | | |
| <u>Micropterus punctulatus</u> | | | | | | | |
| <u>Pomoxis annularis</u> | | | | | | | |
| <u>Etheostoma gracile</u> | | | | | | 1 | |
| <u>Percina caprodes</u> | | | | | | | |
| Total Fish | 7 | 24 | 31 | 50 | 113 | 491 | 2 |
| No. of Collections | 1 | 1 | 2 | 1 | 1 | 1 | 1 |

Table 23 (continued).

| <u>Species</u> | <u>Location</u> | | | | | | |
|--------------------------------|-----------------------|----------------------|-------------------------|---------------------|------------------|------------------------|-----------------------------------|
| | Scott Cr. Hwy 2071 | Spring Cr. Hwy 35 | Hockley Cr. Hwy 2071 | Isle du Bois Cr. | Several sites | Sand Branch Hwy 455 | Clear Cr. Hartlee Field Rd. |
| <u>Dorosoma cepedianum</u> | | | | | | | 12 |
| <u>Notemigonus crysoleucas</u> | 1 | | 8 | | | 2 | |
| <u>Notropis lutrensis</u> | | | 3 | 439 | | | 2886 |
| <u>Notropis shumardi</u> | | 5 | | | | | |
| <u>Pimephales vigilax</u> | | 1 | | 6 | | | 6 |
| <u>Notropis venustus</u> | | | | | | | |
| <u>Minytrema melanops</u> | | 1 | | | | | |
| <u>Menidia audens</u> | | | | | | | 6 |
| <u>Ictalurus melas</u> | | | 2 | 1 | | | |
| <u>Ictalurus punctatus</u> | | | | | | | 1 |
| <u>Fundulus notatus</u> | 2 | 7 | | 1 | | 1 | |
| <u>Gambusia affinis</u> | | | | 4 | | | 6 |
| <u>Lepomis cyanellus</u> | 2 | 14 | 6 | 3 | | 3 | 3 |
| <u>Lepomis gulosus</u> | | | | | | | |
| <u>Lepomis humilis</u> | | 4 | 2 | 1 | | | |
| <u>Lepomis macrochirus</u> | 6 | | | 2 | | | 3 |
| <u>Lepomis marginatus</u> | 1 | | | 2 | | | |
| <u>Lepomis megalotis</u> | | | | 1 | | | |
| <u>Micropterus salmoides</u> | | 2 | | 7 | | | |
| <u>Micropterus punctulatus</u> | | 2 | | | | | |
| <u>Pomoxis annularis</u> | | | | 1 | | | |
| <u>Etheostoma gracile</u> | | 1 | | 1 | | | |
| <u>Percina caprodes</u> | | 1 | | | | | |
| Total Fish | 12 | 36 | 21 | 469 | | 6 | 2923 |
| Sum = 4185 | | | | | | | |
| No. of Collections | 1 | 1 | 1 | 5 | | 1 | 3 |
| Sum = 20 | | | | | | | |

Table 24. Catch of fish from six small ponds and stock tanks to be inundated by the Aubrey Reservoir.

| <u>Species</u> | <u>Tank or Pond Number</u> | | | | | |
|--------------------------------|----------------------------|----|----|----|----|----|
| | #1 | #2 | #3 | #4 | #5 | #6 |
| <u>Notemigonus crysoleucas</u> | | | 6 | 4 | | 5 |
| <u>Ictalurus punctatus</u> | * | * | 2 | | | |
| <u>Ictalurus melas</u> | | | 10 | | | 6 |
| <u>Lepomis gulosus</u> | | 1 | | | | |
| <u>Lepomis macrochirus</u> | 12 | 39 | | 2 | | |
| <u>Lepomis microlophus</u> | 49 | 3 | | 1 | | |
| <u>Lepomis megalotis</u> | 1 | | | | | |
| <u>Lepomis cyanellus</u> | | | 11 | | 41 | 7 |
| <u>Micropterus salmoides</u> | * | * | | | | 1 |
| <u>Pomoxis annularis</u> | 1 | * | | | | |
| Total Fish | 63 | 43 | 29 | 7 | 41 | 19 |
| Sum = 202 | | | | | | |

* These fish present according to land owner or fishermen interviewed.

Amphibians and Reptiles

Although there are numerous studies of the life histories and geographic distribution of amphibians and reptiles, few quantitative data are available on densities of their populations and their roles in the dynamics (productivity, energy flow, etc.) and stability of ecosystems. Data on population densities of amphibians and reptiles are extremely difficult to gather because their secretive behavior and avoidance of traps preclude random sampling. Recent studies of their energetics and metabolism (43, 44, 45, 46, 47) indicate amphibians and reptiles are extremely efficient in converting ingested calories into secondary production; they dissipate relatively little energy as metabolic heat. Consequently, they probably have important roles in the energy flow and production dynamics of ecosystems. Their opportunistic carnivorous habit suggests they may function in regulation of numerous populations of invertebrate and vertebrate herbivores.

However, until more data concerning their roles in the dynamics and regulation of ecosystems are available, quantitative assessment of the environmental impact of changes in population densities and species diversity of amphibians and reptiles produced by reservoir projects is not possible. Therefore, the objectives of this report were to provide a list of amphibians and reptiles which are or should be in the Aubrey Reservoir site; and a general qualitative assessment of the changes in amphibians and reptiles that will be produced by impoundment.

The presence lists of amphibians and reptiles which appear in Tables 25 and 26 below were obtained by direct field observations and from the literature. Field observations were taken in three major "natural" habitat types (old field, upland forest and streamside forest), at farm ponds and stock tanks, along roads, and in and along the banks of streams in the Aubrey Reservoir site. Observations also were made during several canoe trips in Elm Fork. The major literature sources used are listed in the literature cited section (48-56). Considerable information was taken from Telfair (56).

The qualitative assessment of the environmental impact of the reservoir is that impoundment will have an overall

positive effect on the populations of amphibians and certain reptiles. Frogs and toads, the bulk of the amphibians, should benefit from the increase in standing water. The same is true for turtles and water snakes. Lizards and terrestrial snakes will be reduced in number by removal of a significant portion of their habitat. However, if a zone around the reservoir is permitted to "return to nature," populations of the more terrestrial amphibians and reptiles should increase in number. Since the roles of amphibians and reptiles in the dynamics and stability of ecosystems probably are important enough for consideration, it is recommended that a zone around the Aubrey Reservoir be permitted to undergo natural succession.

Table 25. Presence list, abundance* and habitat of amphibians in the proposed Aubrey Reservoir Site**

| Species | Abundance* | Habitat |
|--|------------|--|
| <u>Ambystoma texanum</u> Small-mouthed salamander | ++ | In or near ponds or streams; often under rocks and debris |
| <u>Scaphiopus holbrooki</u> Eastern spadefoot | +++ | In or near temporary breeding ponds in pastureland |
| <u>Bufo debilis</u> Girard -- Green Toad | +++ | Rocky hillsides and grasslands; often under rocks |
| <u>Bufo speciosus</u> Girard -- Texas Toad | +++ | City streets, county roads and temporary pools of water in grasslands |
| <u>Bufo woodhousei</u> Girard -- Woodhouse's Toad | +++ | City streets, county roads, gardens, temporary pools of water in grasslands, ponds |

Table 25 (continued).

| Species | Abundance* | Habitat |
|---|------------|---|
| <u>Acris crepitans</u> Baird -- Cricket Frog | +++ | Ponds, streams, overflows, streamside forests |
| <u>Hyla cinerea</u> Green Treefrog | + | Emergent and marginal vegetation in semi-permanent to permanent ponds and streams |
| <u>Pseudacris clarki</u> Spotted Chorus Frog | +++ | Streamsides bordered by pasture, ponds, temporary rain pools |
| <u>Rana castesbeiana</u> Shaw -- Bullfrog | +++ | Ponds, streamsides, and reservoirs |
| <u>Rana pipiens</u> Schreber -- Leopard Frog | ++ | Ponds, streamsides, and reservoirs |
| <u>Gastrophryne olivacea</u> Western Narrow-mouthed Toad | + | Under rocks or logs in pastureland |

* Rare = +
Occasional = ++
Common = +++

**After Telfair (56).

Table 26. Presence list, abundance* and habitat of reptiles
in the proposed Aubrey Reservoir site**

| Species | Abundance* | Habitat |
|---|------------|---|
| <u>Chelydra serpentina</u> Snapping Turtle | +++ | Ponds, ditches, streams; sometimes seen on roads |
| <u>Kinosternon flavescens</u> Yellow Mud Turtle | +++ | As above |
| <u>Kinosternon subrubrum</u> Common Mud Turtle | ++ | Rivers, creeks, ponds and reservoirs |
| <u>Sternotherus carinatus</u> Keel-backed Musk Turtle | ++ | The Elm Fork, Hickory Creek, and Roarck Branch |
| <u>Deirochelys reticularia</u> Chicken Turtle | ++ | The Elm Fork, Clear Creek and Garza-Little Elm Reservoir |
| <u>Graptemys pseudogeo- graphica</u> Gray-False Map Turtle | + | The Elm Fork |
| <u>Pseudemys scripta</u> Pond Slider | +++ | Ponds, streams, reservoirs; most often observed sunning on logs and sometimes seen on roads |
| <u>Terrapene carolina</u> Box Turtle | ++ | Grasslands and on county roads |
| <u>Terrapene ornata</u> Western Box Turtle | +++ | Grasslands, woodlands, streamside forests, residential areas, pastures, county roads |

Table 26 (continued).

| Species | Abundance | Habitat |
|--|-----------|---|
| <u>Trionyx spinifer</u> LeSueur -- Spiny Softshell | +++ | Ponds and streams with sandy shores and sandbars |
| <u>Anolis carolinensis</u> Voigt -- Green Anole | + | Flower garden, grass in pasture (Purple Three-awn -- <u>Aristida</u> <u>purpurea</u>) |
| <u>Crotaphytus collaris</u> Collared Lizard | + | Gravel pit, limestone and sandstone areas |
| <u>Phrynosoma cornutum</u> Texas Horned Lizard | ++ | Flower beds, yards, rocky fields, county roads, dry areas in fields near ant beds |
| <u>Sceloporus olivaceus</u> Texas Spiny Lizard | +++ | Bases of trees, shrubbery, in and on old wood piles, under logs, around and in old deserted houses or barns |
| <u>Sceloporus undulatus</u> Eastern Fence Lizard | ++ | Rocky fields, heavy brush and tree stumps |
| <u>Ophisaurus attenuatus</u> Baird -- Slender Grass Lizard | ++ | Under logs, in water of creeks, and sandy to gravel areas |
| <u>Cnemidophorus sexlineatus</u> Six-lined Racerunner | + | Rocky areas, sandy fields, hilly areas |
| <u>Eumeces fasciatus</u> Five-lined Skink | + | Hibernating under rotten log in streamside forest near Olivers Creek and Pilot Knob (wooded sand- stone knob) |

Table 26 (continued)

| Species | Abundance* | Habitat |
|--|------------|---|
| <u>Eumeces septentrioalis</u> Prairie Skink | +++ | Prairie with sparse vegetation, rocky areas, and sandy soils interspersed with oaks, rotting logs in stream-side forests, marginal vegetation at edges of ponds |
| <u>Lygosoma laterale</u> Ground Skink | +++ | Floodplains with streamside forests, under decayed logs and rocks in sandy pastures, rocky wooded slopes, rock and sand areas interspersed with oak, oak-hickory associations, residential area |
| <u>Coluber constrictor</u> Linnaeus -- Racer | ++ | Under logs, in rock piles, and often seen on county roads |
| <u>Diadophis punctatus</u> Eastern Ringneck Snake | ++ | Sandy to rocky areas on hillsides, often under rocks and boards |
| <u>Elaphe obsoleta</u> Rat Snake | ++ | Under bridges, creek bottoms, hollow trees, rotting logs, floodplains and hillsides |
| <u>Haldea striatula</u> Rough Earth Snake | +++ | Rocky slopes, beneath planks and old boards; often under flat rocks in fields |

Table 26 (continued).

| Species | Abundance | Habitat |
|--|-----------|--|
| <u>Masticophis flagellum</u> Coachwhip | +++ | Pastures, rocky slopes, grasslands, river bottoms, gravel pits, county roads |
| <u>Natrix erythrogaster</u> Plain-bellied Water Snake | ++ | Creeks |
| <u>Natrix rhombifera</u> Diamond-backed Water Snake | +++ | Ponds and streams |
| <u>Opheodrys aestivus</u> Rough Green Snake | +++ | Shrubs, underbrush, <u>Smilax</u> tangles; mostly occurs along stream systems |
| <u>Pituophis melanoleucas</u> Bull Snake | ++ | Open fields and farmlands |
| <u>Tantilla gracilis</u> Flat-headed Snake | +++ | Rocky hillsides and fields, sandy to rocky pastures. Found most often under rocks |
| <u>Thamnophis proximus</u> Western Ribbon Snake | ++ | Streams and ponds usually at water's edge in marginal vegetation |
| <u>Agkistrodon contortrix</u> Copperhead | ++ | Rock piles, oak wood- lands, rocky hillsides, floodplains, and county roads |
| <u>Agkistrodon piscivorus</u> Cottonmouth | +++ | Wooded streams, ponds with much marginal vegetation |

* Rare = +
Occasional = ++
Common = +++

**After Telfair (56).

Birds

The presence of wild birds provides a positive esthetic value to an area and enhances the enjoyment of an area by visitors and local inhabitants.

To assess the bird populations on the Aubrey Reservoir site, eight observation sites were selected which included the major habitats for birds of the area. These were grasslands, upland forests, streamside forests, and cultivated fields. Birds are classed as common, occasionally seen, and rarely seen. These classes of occurrence are only for the site and not general to outlying areas.

A summary of the birds present as residents or migrants during the study period and those previously reported for the area by Rylander (57) is presented in Table 27 below.

Thirty-six species of birds are residents in the area. Only two of these are considered rare for the site. Forty-seven species are migrants in the area, and eight occur on rare occasions. The species that are considered rare are widespread over much of the United States and are not endangered by the reservoir.

The reservoir site is somewhat depauperate of birds, possibly due to loss of habitat as a result of grazing. It is recommended that a buffer zone around the proposed reservoir be established to insure reinvasion of natural vegetation for birds and other wildlife.

Table 27. Birds of the Aubrey Reservoir Site, Denton and Cooke Counties, Texas

| Species | Resident | Migratory |
|-------------------|----------|-----------|
| Great Blue Heron | | ++ |
| Green Heron | | ++ |
| Little Blue Heron | | ++ |
| Common Egret | | ++ |
| Gadwall | | ++ |
| Pintail | | ++ |
| Green-Winged Teal | | + |
| Blue-Winged Teal | ++ | |

Table 27 (continued).

| Species* | Resident | Migratory |
|---------------------------|----------|-----------|
| American Widgeon | | ++ |
| Shoveler | | ++ |
| Redhead Duck | | ++ |
| Turkey Vulture | +++ | |
| Black Vulture | + | |
| Cooper's Hawk | + | |
| Red-Tailed Hawk | ++ | |
| Swainson's Hawk | | + |
| Marsh Hawk | ++ | |
| Sparrow Hawk | ++ | |
| Bobwhite | ++ | |
| American Coot | ++ | |
| Kildeer | +++ | |
| Upland Plover | | + |
| Spotted Sandpiper | | + |
| Sandpiper | | ++ |
| Mourning Dove | ++ | |
| Screech Owl | ++ | |
| Great Horned Owl | + | |
| Chuck-Wills-Widow | | ++ |
| Common Nighthawk | | ++ |
| Chimney Swift | | +++ |
| Ruby Throated Hummingbird | | ++ |
| Black Chinned Hummingbird | | + |
| Belted Kingfisher | ++ | |
| Yellow Shafted Flicker | | ++ |
| Red-Bellied Woodpecker | +++ | |
| Downy Woodpecker | +++ | |
| Eastern Kingbird | | ++ |
| Scissor-tailed Flycatcher | +++ | |
| Great-crested Glycatcher | | ++ |
| Eastern Wood Peewee | | + |
| Horned Lark | ++ | |
| Bank Swallow | | ++ |
| Barn Swallow | | ++ |
| Cliff Swallow | | + |
| Bluejay | +++ | |
| Crow | ++ | |
| Carolina Chickadee | ++ | |
| Tufted Titmouse | +++ | |

Table 27 (continued).

| Species* | Resident | Migratory |
|------------------------|----------|-----------|
| Brown Creeper | | + |
| House Wren | | ++ |
| Carolina Wren | ++ | |
| Mockingbird | +++ | |
| Catbird | | ++ |
| Brown Thrasher | ++ | |
| Robin | +++ | |
| Eastern Bluebird | ++ | |
| Cedar Waxwing | | ++ |
| Loggerhead Waxwing | +++ | |
| Starling | +++ | |
| Red-eyed Vireo | | ++ |
| Warblers (various) | | ++ |
| House Sparrow | +++ | |
| Eastern Meadowlark | +++ | |
| Redwinged Blackbird | ++ | |
| Orchard Oriole | | + |
| Boat-tailed Grackle | ++ | |
| Cowbird | ++ | |
| Cardinal | +++ | |
| Blue Grosbeak | | ++ |
| Indigo Bunting | | ++ |
| Painted Bunting | | + |
| Dickcissel | | ++ |
| Savannah Sparrow | | +++ |
| Vesper Sparrow | | ++ |
| Lark Sparrow | | +++ |
| Goldfinch | + | |
| Slate-colored Junco | | ++ |
| Field Sparrow | | +++ |
| Harris' Sparrow | | ++ |
| White Crowned Sparrow | | ++ |
| White Throated Sparrow | | ++ |
| Lincoln's Sparrow | | ++ |
| Song Sparrow | | ++ |

* + = rare; ++ = occasional; +++ = common

Mammals

The presence of wild native mammals provides a positive esthetic value to any area, and many species of mammals, especially those which are easily observed during daylight hours, enhance the enjoyment of an area by visitors and local inhabitants.

To assess the mammalian fauna of the Aubrey Reservoir site, eight collecting sites were selected which included the major natural habitats for mammals of the area. These were grasslands, upland forests, and streamside forests. One hundred live-traps were set for three nights in a grid of 10 rows with 10 traps per row. Assessment of abundance of large mammals was made by driving roads throughout the area and one boat trip down a portion of Elm Fork of the Trinity river, in addition to communications with local Texas Fish and Game officials and inhabitants of the area.

A summary of the mammals present during the study period and those previously reported for the area by Davis (58) are presented in Table 28 below.

Twenty six species of native mammals occur on the proposed reservoir site, and, of these, nine are considered to be rare in occurrence. Although rare in this area, they are all widespread over much of the United States, and none of the species are considered endangered by the reservoir. In fact, within 10 to 15 years the potential of the area adjacent to the reservoir as a habitat for these mammals will be enhanced, and several of the species should increase in numbers.

The three habitats studies support about equal numbers of species of mammals. Of the three habitats, grasslands have the potential for supporting the largest populations, especially rodents. Native or near-native grasslands occur rarely on the site, and grazing has resulted in a depletion of this habitat. Even the upland and streamside forest have been disturbed and altered by grazing so that mammal populations have been reduced. It is recommended that a buffer zone of restricted grazing be established near the reservoir to insure reinvasion of natural plant communities for native mammals.

Few mammals on the site can be considered to be of economic importance. Large carnivores are rare in occurrence.

Those species of interest to the hunter include only fox squirrels and white-tail deer. The former are seen occasionally and provide a limited source for hunting pleasure. Deer are rare in the area, and only several years of reforestation would allow for their return.

Table 28. Mammals of the Aubrey Reservoir Site, Denton and Cooke Counties, Texas

| Species* | Habitat | | |
|--|-----------|---------------|-------------------|
| | Grassland | Upland Forest | Streamside Forest |
| Opossum, <u>Didelphis marsupialis</u> | | +++ | +++ |
| Armadillo, <u>Dosypus novemcinctus</u> | ++ | ++ | |
| Red bat, <u>Losueruis borealis</u> | | ++ | ++ |
| Raccoon, <u>Procyon lotor</u> | | ++ | +++ |
| Ringtail, <u>Bassariscus astutus</u> | | + | |
| Spotted skunk, <u>Spilogale putorius</u> | | + | |
| Striped skunk, <u>Mephitis mephitis</u> | + | ++ | + |
| Gray fox, <u>Urocyon cinereoargenteus</u> | | + | |
| Coyote, <u>Canis lotrans</u> | + | + | |
| Fox squirrel, <u>Sciurus niger</u> | | ++ | ++ |
| Pocket gopher, <u>Geomys bursarius</u> | ++ | | |
| Hispid pocket mouse, <u>Perognathus hispidus</u> | + | | + |
| Long-tailed harvest mouse, <u>Reithrodontomys fulvescens</u> | ++ | | |
| Gray harvest mouse, <u>Reithrodontomys montanus</u> | ++ | | |
| Deer Mouse, <u>Peromyscus maniculatus</u> | ++ | | |
| White-footed mouse, <u>Peromyscus leucopus</u> | | ++ | ++ |
| Cotton rat, <u>Sigmodon hispidus</u> | +++ | | |
| Eastern wood rat, <u>Neotoma floridana</u> | | + | + |
| Muskrat, <u>Ondatra zibethicus</u> | | | ++ |
| Nutria, <u>Myocastor coypus</u> | | | + |
| Housemouse, <u>Mus musculus</u> | ++ | | |
| Jack rabbit, <u>Lepus californicus</u> | + | | |
| Cottontail, <u>Sylvilagus floridanus</u> | +++ | | |
| Swamp rabbit, <u>Sylvilagus aquaticus</u> | | | + |
| White-tail deer, <u>Odocoileus virginianus</u> | | + | + |

* + = rare, ++ = occasional, +++ = common

Archaeological - Historical - Cultural Elements

This study was undertaken in order to examine the archaeological, ethno-historical and historical elements that would be affected by the proposed construction of what is referred to as the Aubrey Reservoir. The proposed site, located just below the juncture of the Elm Fork and Isle du Bois Creeks, would flood a portion of the northern part of Denton County, southern Cooke County and southwestern Grayson County. Most of the area to be flooded lies in the Eastern Cross Timbers, while a small portion extends into the Grand Prairie.

Four archaeological periods have been defined in the area of north central Texas where the proposed Aubrey Reservoir site lies. These are the Paleo-Indian stage (? - 7,000 BP), Archaic stage (6,000 BP - AD 500), Neo-American (AD 500 - AD 1541), and Historic (AD 1541 - Present). The exact dates are used only for convenience, because no abrupt changes occurred at those dates (32). Amateur and professional archaeologists have identified sites from the Archaic stage in the north central Texas area. A few relics from the Paleo-Indian stage were found in some of the sites (59, 60, 61, 62, 63, 64).

Several sites from the Neo-American stage and associated with the Henrietta Focus, which began about AD 1450 and lasted until some time after 1600, have been found in the Elm Fork region; at least one recorded site exists within the perimeter of the proposed Aubrey Reservoir site (32, 65, 66, 67, 68). A previously unrecorded site was uncovered during the field study for this report. References were made by older people interviewed to additional Indian burial grounds in the site. These references were too vague to enable us to uncover the sites in the short time allotted for the study. Discovery and evacuation of archaeological sites in a 35,050 acre area require considerably more than the months time allotted to this study. Literature is scanty on the archaeology of the site area because archaeologists have not been as active in the area north of Denton as they have been in the Dallas area and on the lower part of the Elm Fork of the Trinity (31, 69). Consequently, an extrapolation from the existing literature descriptions of sites found around Denton and in the lower Elm Fork area to the Aubrey site

was used to make an estimate of the probable archaeological impact of the Aubrey Reservoir. The archaeological discoveries in the lower Elm Fork area and reports by older residents in the Aubrey area suggest that the site area should be intensively investigated by professional archaeologists. Since this will require at least 1 year, we recommend a study team be assembled and funded immediately for this purpose.

Technically, recorded history in Texas begins in the 1540's and archaeology ends. Yet as far as the literature goes, recorded history on the Elm Fork of the Trinity does not actually begin until Anglo settlement of the region began in the 1840's and 1850's. Although the Spaniards were on the Gulf Coast and the lower Trinity in the late 17th century (70), the French had posts on the Red River by 1716 (71), and Spanish expeditions in the late 17th and 18th centuries penetrated to the Red River, there is not evidence of these groups passing through the Elm Fork area (72). Indians apparently were the only ones to use the land in this area without challenge until near the mid-19th century.

In dealing with the impact of the proposed reservoir in this report, the era between 1541 and the mid-19th century was considered a part of the archaeological parameter; it should, technically be called ethnohistory. The ethnohistory of the Elm Fork is little known and virtually undocumented. Considerably more is known about the major Caddoan tribes located to the south on the Trinity and Neches rivers and to the north and east on the Red River (73, 74, 75). The Elm Fork area was inhabited by the Kichai Indians of Caddo stock, at least from about 1700 to the mid-19th century when they were confined to a reservation on the Brazos River (31). As far as can be ascertained from the literature no major Kichai villages existed within the site of the proposed Aubrey Reservoir--at least not on the eve of Anglo settlement. The aforementioned burial grounds do indicate that some Indians inhabited the site. References are made to temporary camps for hunting and fishing in the mid-19th century, but none were said to be located directly in the proposed reservoir area (30). This little can be gleaned from the literature; no ethnohistory can be gained from the memories of living inhabitants. The only recourse is to the methods of archaeology and, again adequate field surveys could

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be conducted. Undoubtedly, other Indian sites occur in the area and with a systematic survey, could be found prior to inundation.

Settlement began in the area of the proposed reservoir in the mid- and latter part of the 1840's (30) as settlers began moving into both the Eastern Cross Timbers and the Elm Fork bottom land. Both sections reached their peaks in population and intensive land use between 1890 and 1920. The Eastern Cross Timbers and the Elm Fork bottom were areas of intense cotton cultivation in those times. Although exact data are not available, the population size in the area to be inundated was roughly as high as it is today. Northern Denton and southern Cooke counties were settled earlier than areas to the west for two reasons: 1) the available timber which was absent from the prairie immediately to the west; and 2) the sandy loam soil was easier to plow with the crude implements of the 19th century than was the black land soil of the prairies to the west. Consequently, the prairie land to the west was later monopolized by the cattle ranchers. The cattlemen also provided something of a buffer between the Indians to the north and west and the farmers who had settled in the Eastern Cross Timbers and Elm Fork bottom.

The decline of cotton cultivation in the last three or four decades resulted from the erosion and wearing out of the thin sandy soil of the Cross Timbers and shift to livestock grazing, haying and dairying in the Elm Fork bottom. In recent years there has been some revival in the Cross Timbers as former urbanites from Denton and Dallas have begun to buy up the old lands, clear them, sprig them in Coastal Bermuda grass, fertilize and graze them intensively. This is a movement that would undoubtedly continue as the Dallas-Fort Worth area continues to grow.

Historical literature on the era since settlement began, that deals specifically with the land to be inundated, is extremely meager and that which is available is in some cases not satisfactory. County histories, reminiscences of older citizens, and soil surveys have been extensively examined for whatever was useful. County historical survey committees in the respective counties were contacted to learn if any state historical markers were located in the site to be inundated, or if not, whether plans existed to place any. Any other historical information they could offer was solicited. Older people who had lived in the

area for many years were interviewed, and several field trips were made through the area; all the cemeteries and family plots were visited, the number of graves counted, and names and dates noted for possible further investigation. Due to a lack of time; files of local newspapers were not used in the research for this study. They could possibly provide some more detail, but an evaluation of the impact of the proposed project on the Historical Elements has been made with considerable confidence that it is accurate, fair and reasonably comprehensive. Fortunately, the professional historian who conducted the research on Archaeological and Historical Elements for this study is a life-long resident of Denton County and from the area adjacent to the proposed reservoir. He knows personally many of the people to be affected and was generally familiar with the history of the area before this study; he is also a member of the Denton County Historical Survey Committee.

Additional material on archaeological and historical aspects of the area are found in the Human Interest Category under the appropriate component and parameters. Because of the extensive treatment in these sections, this report on Historical Elements is reduced in content.

The following are recommendations concerning Archaeological-Historical-Cultural Elements:

1. A field study of the proposed site should be made by archaeologists and the salvage work indicated be done.

2. Historical markers should be placed to mark the sites of Old Bloomfield and Vaughtantown. They should be placed on the perimeter of the reservoir as near to the sites of the communities as possible and still allow good access to them by roads.

3. The grave and the homesite of Dr. John S. Riley should be marked by an historical marker. It would probably be best to mark the site as near the perimeter of the reservoir as possible.

4. The site of St. James Baptist Church should be marked by an historical marker. It would probably be best to mark the site as near the perimeter of the reservoir as possible.

5. If maintenance can be assured, Davis, Strickland, Jones and Bloomfield cemeteries should be moved outside the flood stage of the proposed reservoir; that their names be retained and that they be moved as short a

distance as consonant with obtaining a proper site and good access. If no arrangement for maintenance by governmental authorities can be arranged, then they should be moved into presently established cemeteries. Davis should be moved to Green Valley, Strickland to Sanger, and Jones and Bloomfield to Mt. Pleasant or Walling cemeteries. The family plots should be combined in the following ways:

a. Family plot one should be combined with Davis Cemetery.

b. Family plot two should be combined with Strickland Cemetery.

c. Family plot three and four should be moved to Tyson Cemetery.

These should be the arrangements unless, of course, the members of the families object and wish some other disposition.

6. The Bloomfield Church building should be moved near the newly established cemetery unless the cemetery is moved to a presently established one.

7. Each of the cemeteries should have a state historical marker placed at its new site which would give its original location and its history.

The placing of markers will require that funds be advanced to pay for the markers, since there is no state or county funds appropriated for this purpose. Although the exact cost is not known, it is estimated that no more than \$1,000 would be required. County Historical Survey Committees in the respective counties would have to approve the placing of these markers, but this should be no problem.

8. Cooperation and encouragement should be given to local historians and journalists in ferreting out and publishing or otherwise preserving the history of the area affected by the proposed reservoir.

9. Special financial and leadership assistance should be given to the members of St. James Baptist Church in moving and relocating their building.

10. Special efforts should be made to communicate patiently and clearly with the congregation of St. James Baptist Church on the plans.

Geological-Physical Elements

This report is not a total physical survey of the Aubrey Reservoir site, but instead is a look at the elements that will have a direct effect upon construction and completion of the proposed reservoir. The intent is to emphasize to a higher degree those things that the EES did not consider and give information on the availability of materials that can be used in further study of the area.

Physiography

The proposed site of the Aubrey Reservoir is mainly in the physiographic subregions of the Grand Prairies and the Eastern Cross Timbers. The area is defined and described by Fenneman (76) as a region of sedimentary rocks laid down in the Cretaceous period of time that dips slightly toward the southeast with the strike of the strata along a north south line. The area is one of rolling plains with very wide but shallow valleys in which small streams flow. Many of the streams are intermittent during the dry seasons but may overflow their banks during the periods of heavy rainfall. The creation of the reservoir will form a lake that is very wide in proportion to the depth. The water surface of the reservoir will cover approximately 54 square miles in a total drainage basin of 692 square miles (77). The development of the project will enhance the appreciation of the physiography as more roads are available in the region to travel to a greater number of persons.

Climate

The climate of the region in which the proposed lake is to be built is that of a humid sub-tropical climate. This is a region of long summers and short winters with 222 days that are frost free. It is an area of variability of precipitation from 20.37 to 52.79" and an average of 33.67" received at Gainesville, Texas.

The level of the reservoir will vary greatly with the changes in climatic years. There will be few times that the lake will be filled to the flood stage and then excess waters will be lowered to the conservation level as soon as practical following storms and heavy run-off. Based upon

other reservoirs of the region, the lake will be at less than conservation level over much of the time and a wide expanse of shoreline will be visible.

There are adequate resource materials from several sources that can be used to study the climate and variability of it in the Upper Trinity Basin area. Major sources of materials are those available from the Environmental Science Services Administration (78, 79), Office of the State Climatologist(80), and from the records of the Texas Agricultural Experiment Station located west of Denton.

Geology

The area of the proposed Aubrey Reservoir was studied using existing maps and geological publications (81, 82, 83) from which a field map was drawn of the surface exposures on the USGS topographic sheets. The eastern portion (Plate II) of the area has exposure of the Fort Worth limestone and blue shaly clays. The middle division is mainly shale with the upper division being predominately limestone. The Denton clay immediately overlies the Fort Worth. It consists of 45 to 60 feet of brownish-yellow clay with numerous sandstone beds terminating at the top with a hard, brownish-yellow arenaceous limestone.

The Weno clay overlays the Denton formation and contains larger amounts of iron concretions than the Denton. The top member of the formation is the "Quarry Limestone", a sandy limestone. The Paw Paw formation is more or less irregularly bedded sandy clays and sands (83). The Main Street Formation consists of 10-15 feet of semi-crystalline limestone interbedded with calcareous marl. The Grayson marl is the uppermost formation of the Commanchean (lower Cretaceous) consisting of light colored fossiliferous clays or marls (83).

The Woodbine is the basal member of the Gulf Series of the Cretaceous. It is cross-bedded to a large extent outcropping in a belt varying in width up to seven miles along the eastern part of the reservoir area (Plate II). The valleys have been filled with materials of sands and gravels during the Pleistocene that form terraces along the sides of the streams today. The lower floodplains are silts and sediments of recent alluvium.

Paleontology

The area of the proposed reservoir is extremely rich in a wide variety of invertebrate fossils. A partial listing of fossils and associated formations are listed below (83).

Hemisaster elegans (Schumard) Ft. Worth formation
Holaster simplex (Schumard) Ft. Worth formation
Schloebachia leonensis (Conrad) Ft. Worth formation
Exogyra americana (Marcou) Ft. Worth formation
Gryphea washitaensis (Hill) Ft. Worth formation
Ostrea carinata (Lamarck) Denton formation
Nucula sp. Ostrea quadruplicata (Schumard) Weno formation
Protocardia texana (Conrad) Weno formation
Exogyra arictina (Roemer) Main Street and Grayson formation
Kingena waconensis (Roemer) Main Street
Grapheia muscronata (Gabb) Grayson
Turritities brazonensis (Roemer) Grayson
Some leaves in the Woodbine

Excellent reference sources for the study of paleontology for the region around the Aubrey Reservoir site available include: The Geology of Cooke County, Texas, University of Texas Bulletin No. 2710, The Geology of Denton County, University of Texas Bulletin No. 2544 and Texas Cretaceous Fossils, University of Texas Bulletin No. 2838 (84).

Economic production within the reservoir area that will be lost as a result of the flooding of the land will include that of numerous sand and gravel pits that are a source of material used as construction aggregate and for road building by the local counties. There will also be the inundation of the Jacobs Oil Field. This should be considered as a possible source of pollution.

Soils

The soils of the region are a complex mixture mainly of clays and sandy loams. The printed soil surveys are out of date and newer surveys have not been completed and printed. Denton County had a soil survey printed in 1922 (85). Denton County is being surveyed at the present time but there are many of the portions of the reservoir area that have not been completed. The Soil Conservation Service for the Upper Elm and Red have completed all of the field

work and mapping of the area within the projected reservoir but publication has not taken place. The environmental impact on soils will change little from its present state as a result of the construction of the project.

Hydrology-Water Quality Elements

The availability of water of acceptable quality is frequently a limiting factor to the growth and development of a geographical area. The physical, biological, and chemical characteristics of available water in an area often imposes limitations and restrictions on the manner in which the water will be consumed. Also, if the raw water is unpalatable and not satisfactory for specific uses, the type and extent of treatment needed must be determined by chemical and biological analyses.

The chemical and biological constituents of natural water are dependent on environmental factors such as the types of soil through which the water travels, patterns and characteristics of stream flow, and the activities of man.

The chemical quality of surface water in the Trinity River Basin is generally acceptable, and with minimum treatment, the water is suitable for domestic, industrial, and irrigation use (Texas Water Development, Report #67, 1967). However, in contrast to this statement, the Texas State Health Department concluded in 1960 that the upper Trinity River and its tributaries contained water of poor organic quality as a result of inadequately treated sewage and self-stabilization was retarded because of low flows. Furthermore, the report stated that population increases in the area will demand better and more efficient waste treatment facilities if gross pollution of streams is to be avoided in the future. Such cases are more prevalent and immediate in areas downstream from the proposed Aubrey project site. The problem is not as critical in the Aubrey site area at the present time as it will be.

Certain characteristics will occur with impoundment of water in the Aubrey Reservoir. Some of the predictable beneficial changes that will occur are: lesser variations in the temperature, turbidity, color, and a decrease in the number of coliform bacteria. On the other hand, detrimental effects of impoundment include increased dissolved solids and hardness resulting from evaporation, a reduction in dissolved oxygen because of an increase in the biochemical

oxygen demand, and an increase in algal growth due to an influx of nutrients.

In order to determine the present water quality in the upper Trinity River Basin, grab samples were collected weekly from strategically located stations. The stations chosen, would yield chemical and bacteriological data that are indicative of the water quality in this particular section of the watershed.

The stations chosen for the study are listed in an order from north to south downstream. Station I-35 is located south, southwest of the city of Gainesville, Texas, on the upper fork of the Elm Fork Creek. This station is approximately 0.25 miles above the outfall of Gainesville's wastewater effluent. The station designated GE is located about 0.75 miles below the wastewater outfall. Station EF is located at the bridge on the Elm Fork Creek on FM road 455 east of Sanger, Texas, and Station duB is located at the bridge over Isle duBois Creek on FM road 455 west of Aubrey.

Soil samples were collected in conjunction with water samples in order to determine the quantities of available soluble materials that will ultimately be dissolved in the water of the reservoir. The chemical samples, placed in screw-cap polyethylene bottles, were either analysed on the same day they were taken, or stored in the refrigerator for a period of time not exceeding 24 hr. The bacteriological samples were collected aseptically with a modified ZoBell water sampler and transferred into sterile dilution bottles and stored in ice. Qualitative and quantitative determinations were made on these samples within 2 hr after collection.

Thorough chemical and bacteriological investigations were made on the samples to gain some knowledge concerning the total constituents of the water. Most of the samples were collected when the creeks were at normal or low flow. However, a few samples were obtained following light rains which only slightly changed the depth and flow of the streams. Influx patterns in test data were not observed during these periods of sampling.

The present quality of the water in the proposed reservoir basin was determined by laboratory tests according to Standard Methods (21). These tests included the following analyses: biochemical oxygen demand, dissolved oxygen, total carbon, organic and inorganic carbon, total nitrogen (including nitrate, and ammonia nitrogen), inorganic phosphates, chlorides, iron, specific conductivity, pH, alkalinity, hardness, total dissolved solids, and complete bacteriological analyses. The bacteriological tests consisted of total

coliform MPN, fecal coliform MPN, fecal enterococci MPN, and total plate counts. Also, the predominant genera were determined for each station.

All of the parameters included in the Water Pollution component of the Environmental Pollution category of the EES are discussed in ensuing paragraphs. The approach taken will be that of reporting our findings as to the existing quality of water in the upper Trinity River Basin, and, comparing these results to those reported by the Texas Water Development Board. Also, our data will be compared to standards that must have been recommended by the FWPCA. These data will also be used in predictions and recommendations concerning the Aubrey Reservoir Project. However, it is necessary to use discretion and understanding in the evaluation of the quality of raw water because of regional variations. Probably the most important criterion to consider in developing water quality standards is the health of the consumers. This factor will be considered in any recommendation made on the water quality of this region.

Biochemical oxygen demand (BOD) determinations obtained in this study were derived in part from extrapolated organic carbon data and actual 5-day BOD runs. Calculations showed that each milligram of organic carbon in a sample required 2.7 milligrams of oxygen for oxidation if the materials were biodegradable in 5 days. The range for the four stations in this study showed 6-26 mg/l of organic carbon. The weighted average for all samples was 12 mg/l. The highest BOD's came from station GE where the stream contained a heavy organic burden of sewage effluents (30 mg/l). However, at the Elm Fork station, the concentration was reduced appreciably to an average BOD of 5.1 mg/l, demonstrating that biological oxidation has occurred. The mean dissolved oxygen concentration at this point was 7.2 ppm, indicating that substantial stress was not placed on the DO at this station. The BOD concentration is expected to decrease when the project is constructed. However, following inundation of the land, soluble organic materials may cause some minor increases in the BOD of the reservoir.

Tests revealed that dissolved oxygen concentrations were ample to support aquatic life. However, the station below the Gainesville outfall (GE) had a DO range from 3.5-6.7 mg/l with a weighted mean value of 5.1 mg/l.

This concentration is low for diversified warmwater biota which require a DO concentration at least 5 mg/l. Concentrations at or near saturation are desirable for coldwater biota (FWPCA). It should be noted at this point that, for the most part, conditions at this collecting station were quite static during the majority of the test period.

Dissolved oxygen is also useful in water in aiding the removal of iron and manganese. DO also oxidizes nitrite and ammonia nitrogen to the nitrate form that serves as a terminal electron acceptor in certain microorganisms under anaerobic conditions. Standards have not been established for this parameter, however, the BOD concentration of a samples indicates the quantity of pollution in a water source.

The DO parameter is not predicted to become critical and have a negative impact on the project. The stabilization requirements of BOD in the future, for the most part, will not cause undue stress on the DO concentrations in the reservoir. The DO levels in the future may be dependent on wastes and other organic materials reaching the reservoir, but this can be negated somewhat by improving facilities at wastewater disposal plants to more effectively remove matter which contributes to BOD.

Nitrite, nitrate, and ammonia analyses were performed on all samples, and a total nitrogen concentration was obtained. Ammonia is sued as an indicator of recent fecal pollution, and it places stress on the dissolved oxygen. Nitrite and nitrate nitrogen have been implicated in infant methemoglobinemia (86, 87). The toxicity of ammonia is markedly increased by reduced DO concentrations (88). Also, at pH levels of 8.0 and above, the total ammonia expressed as nitrogen should not exceed 1.5 mg/l (89). A concentration of 2.5 mg/l total ammonia is acutely toxic (FWPCA). Based on these and other findings, nitrate concentration should not exceed 10 mg/l and nitrite level should not exceed 1 mg/l due to their toxicities (NAS). However, the FWPCA recommends that the combined total of nitrite-nitrate nitrogen should not exceed 10 mg/l.

Results reported by the Texas Water Development Board showed that the weighted mean value for nitrates in the upper Trinity River Basin for the period 1952-1967 was 715 ppm with a range of 0-118 ppm. The following nitrite-nitrate mean values were obtained in the present study: I-35, 0.33 ppm; GE, 0.48 ppm; EF, 1.18 ppm; and

duB, 0.25 ppm. These concentrations are well within the recommended limits (FWPCA, 1968).

The highest concentrations of ammonia were detected at the station receiving the Gainesville wastewater effluent, GE. This was expected since this samples was collected very near the effluent outfall from a sluggish area in the creek. Biological oxidation was evident farther downstream as the ammonia concentration was reduced at station EF. The ammonia ion constituted 86% of the total nitrogen at station GE and was reduced to 23% at the Elm Fork station.

The water of the upper Trinity River Basin varies in hardness from 121-180 ppm in the northern part of the basin to less than 60 ppm in the central and extreme southern parts. The northern part contains rocks of the Cretaceous age while the central and southern parts contain younger rock formations. Consequently, the water is medium hard in the northern region and generally softer in the central and southern regions.

Phosphorus is an essential element for all forms of life. The role of phosphates in productivity and eutrophication processes have been the subject of extensive research.

Levels of phosphate will vary from one stream or reservoir to another. Water impounded in reservoirs normally shows a reduction of phosphorus due to biological uptake or precipitation (FWPCA). Therefore, it is assumed that a decrease in the phosphate content will occur in the Aubrey Reservoir. Relatively uncontaminated lakes have 10-30 mg/l total phosphorus (FWPCA), however, some potable water supplies now exceed 200 mg/l. It is apparent that more research is necessary in order that phosphorus concentration limitations be well authenticated. Hence, no limits on phosphates are recommended at this time by the EPA and APHS, although, minimum and maximum concentrations should be determined by conditions that exist in a specific reservoir.

Phosphate analysis by sample is as follows: I-35, 42 ug/l; GE, 1610 ug/l; Elm Fork, 520 ug/l; and duB, 50 ug/l. These concentrations are expressed as mean values. The heaviest loading occurred at GE, and, it is most likely attributable to detergents in the domestic wastewater which had not been removed or degraded. Also, agricultural runoff from areas above Gainesville may add to the concentrations. However, substantial reduction is observed downstream at the Elm Fork station, but the remaining level of phosphate may be sufficient to

adversely affect the water quality of the reservoir by causing noxious algal blooms. It is of interest to note that there has been concern for some time over the loading of phosphates in Texas reservoirs and projected reservoirs. The 1964 mean for phosphates in the Trinity River was 2.4 mg/l (90).

No tests were taken on pesticides, but mainly to a lack of sufficient time. Additionally, adequate controls were not available at the time of sampling. Pesticide data were obtained from the Texas Water Development Board, and, such data were extrapolated in order that a parameter measurement for the EES could be derived for this area of the basin. Since these data showed that several pesticides were detected at a station 30 miles south of Dallas, it was assumed that these compounds were probably present in the upper Trinity River Basin. This assumption is based on the fact that most chlorinated hydrocarbon pesticides are not degraded in nature and are cumulative and persistent in the environment.

Applied pesticides will certainly continue to gain access to the creeks and ultimately into the reservoir and will remain a constant problem and a threat to the aquatic environment. More research must be done on the toxicological effects of these compounds so that specific limitations and restrictions can be placed on them. The FWPCA has established recommended permissible maximum concentrations for drinking water and surface water.

The turbidity of creeks and reservoirs in this immediate geographical region is variable, and dependent on inherent climatic, physical, and chemical conditions. The turbidity of the proposed reservoir should show improvement over that of the contributing tributaries, as well as that of the reservoirs just below it. Turbidity measurements on Garza-Little Elm Reservoir, and its tributaries have varied from 50-900 JTU in previous studies by the Institute for Environmental Studies (1957-1972). Turbidity measurements in the present study immediately above the proposed dam site ranged from 50-150 JTU with a mean of 115 JTU. This cannot be judged as a representative evaluation because of the short length of time, and lack of flow variation, during the period the samples were collected. However, turbidity is not predicted to have a negative impact on the project.

Toxic substances, not including pesticides, are of great importance to water quality. This group of chemical

compounds contains a myriad of constituents such as oil and petroleum by-products, hydrocarbons, ABS, LAS, PCB, phenolic compounds, cyanide, heavy metals, and domestic and industrial wastes.

Analytical procedures for the detection and quantitation of a majority of these substances have been developed. These toxic chemicals for the most part can be quantitated in very minute concentrations, and maximal permissible levels for drinking water have established by the USDHEW and FWPCA.

The heavy metals have been shown in many studies as being highly toxic in very low concentrations in water. The acute toxicity of zinc and cadmium has been shown to increase with pH (91). Zinc has been shown to be toxic to fish (92) and certain algae (93).

The only conclusive evidence of toxic compounds in the water of this region of the Trinity River Basin is the presence of arsenic in bottom sediments from Garza-Little Elm Reservoir (Dr. Tom Gray, personal communication). The arsenic level was determined to be at least 1 part per 10,000. The arsenic content in drinking water in most United States supplies ranges from a trace to 0.1 mg/l (94).

Certain toxic compounds will perhaps accumulate in the basin of the reservoir through the continued application of certain pesticides and heavy metals on the watershed; and some may be contributed through leaching. Therefore, in time, the possibility exists that critical levels of many of the toxic chemicals may be reached.

The total inorganic carbon tests indicated that inorganic carbon in the tributaries of the Aubrey watershed averages 54 mg/l, which is well below the magnitude (70 mg/l) suggested by Battelle-Columbus to create problems with productivity and eutrophication. It is characteristic for a reduction to occur in the inorganic carbon concentration following impoundment. However, evaporation and input of nutrients by the influent waters will influence productivity and increased carbon levels. The only recommendation regarding inorganic carbon is to prevent excess waste materials from gaining entrance to the reservoir which would serve as nutrients for aquatic organisms, thus increasing the total organic carbon content.

Temperature readings were taken on all samples. The surface temperatures ranged from 18-22 C which is normal for streams in this area during the period of study. The thermal characteristics of the proposed reservoir should

resemble those of Garza-Little Elm. Temperature data from Garza-Little Elm suggest that temperature changes in the Aubrey Reservoir will be seasonal and will not adversely effect water quality or be detrimental to the natural biota.

Impoundment of Elm Creek will result in an overall reduction in the water temperature which will be beneficial to the development of the natural aquatic ecosystem. Since no form of thermal pollution is expected in this region of the water basin, there are no recommendations pertinent to this parameter.

Measurements showed that the hydrogen-ion concentration ranged from 7.72-8.05. The pH may undergo a slight depression following impoundment because of the formation of acids of organic materials which become soluble in the reservoir. However, this change should be very slight and not adversely effect water quality. This is not to say that the hydrogen-ion concentration is not a complicated parameter as it is known that the pH is an integral factor in chemical reactions in water. Although a pH of 7.78-8.0 may be considered to be rather high for waters, as compared to natural lakes, substantial deviation from other reservoirs in this area is not expected to occur.

The basin hydrologic loss was calculated from data obtained from the United States Geological Survey (USGS). Presently, the natural water loss is offset in part, by precipitation. However, as the population increases, more stress will be placed on the quantity water of acceptable quality.

Although the natural runoff pattern in the upper part of the basin has been greatly affected by the construction of small reservoirs in the Denton area, storage in the upper basin has not significantly affected runoff in the lower basin (Texas Water Development Board). Uneven stream flows, variations in rainfall intensity, and temperature make storage projects a necessity in order that surface water will be available in sufficient quantities. Even though the proposed reservoir will affect the stream flow pattern somewhat, no unusual deviation in maximum and minimum variations intense enough to adversely affect the environment is predicted.

Total dissolved solids were determined by extrapolating from specific conductivity results. The range for specific conductivity on the samples was 605-1000 micromhos units. The average for all samples was 731 micromhos units,

which is approximately 500 mg/l total dissolved solids. The main stem of the Trinity River contains concentrations ranging from 250-300 ppm throughout most of its reach. The duration curve for the concentrations of dissolved solids for the Trinity River at Romayor shows that 300 ppm dissolved solids has been equalled or exceeded 50% of the time (Texas Water Development Board). As a rule, there is a gradual decrease in dissolved solids in the Trinity River from north to south. Exceptions are noted, however, in instances where metropolitan areas release sewage effluents and brines from oil wells reach the river.

The concentration of total dissolved solids should not present too much of a problem following impoundment. Actually it is characteristic for dissolved solids to decline during impoundment. Evaporation may occasionally increase total dissolved solids, however, any changes are predicted to lie within the acceptable quality range. Effective control measures must be employed to minimize the addition of salts, oil well and industrial wastes.

Soil samples were taken from five areas in the watershed that will be inundated by the reservoir. The objectives of this part of the study were to determine the quantities of phosphates, nitrites, nitrates, and iron that will be available solutes and ultimately be dissolved in the waters of the reservoir. Test results showed that all of these substances are present in low concentrations in the soil samples that were analysed. The averages for these compounds were: phosphates, 0.66 mg/l. The permissible concentration of iron, as established by the FWPCA, is 0.3 mg/l in surface waters.

The test results of all chemical analyses of this study are contained in Table 29.

Bacteriological analysis were employed in the determination of the overall water quality of the upper Trinity River Basin. Standard methods (21) were used in all of the bacteriological tests, quantitations, and reporting.

Total coliform densities and fecal coliform densities were determined by the MPN multiple-tube technique. These results were used to resolve the amount of fecal pollution inherent to the creeks of this area. The total coliform MPN values ranged from 1.5×10^3 - 6.3×10^5 total coliforms/100 ml with a weighted mean of 1.8×10^5 /100 ml (180,000/100 ml). The FWPCA recommends that the total

coliform count should not exceed 20,000/100 ml. So, the results from this study indicate that this water is of rather poor bacteriological quality.

Fecal coliform densities, as quantitated by MPN results, had a range of 2.1×10^2 - 8.8×10^3 /100 ml with a mean value of 3.2×10^3 /100 ml. The FWPCA also recommends that surface water fecal coliform concentrations not exceed 2,000/100 ml. These results, as shown in Table 30, indicate that a high degree of fecal pollution is not evident at this time. It is predicted that the density of fecal coliforms will decrease following impoundment because of dilution and die-off of fecal coliforms. Also, the city of Gainesville is to receive federal aid for the expansion and improvement of their wastewater facilities. This alone should reduce appreciably the quantity of fecal coliforms reaching the reservoir as a large number of these organisms are now being contributed by this source.

It is of interest to note two other studies concerning fecal coliform densities in river waters. The densities in a particular section of the Missouri River, above a city's intake supply, reached a level of 3.3×10^4 /100 ml (95). In another IES study, (Silvey, et al., unpublished data) it was shown that fecal coliform concentrations in a particular section of the Trinity River in the metropolitan area of Dallas-Ft. Worth reached a level of 1.2×10^6 /100 ml. Both test results, however, reflected high concentrations of fecal coliform organisms due to receiving waste effluents.

Fecal enterococci densities were also determined by MPN procedures. These resultant concentrations were compared to fecal coliform densities and a fecal coliform to fecal enterococci ratio was determined for each station. This ratio can be used to indicate the quantity of fecal pollution. Such a ratio must be applied carefully, but in general, the higher the ratio, the greater the possibility of fecal pollution. Three of the four derived ratios were less than 6/1 fecal coliforms to fecal enterococci which is quite characteristic of river waters. These results are presented in Table 32.

Total plate count determinations were made on every sample. Serial dilutions of each sample were spread on Standard Plate Count Agar and incubated for 24 hr at 37 C. The plates were allowed to set out at room temperature for an additional 24 hr. The colonies on the plates were

counted by means of a Quebec Colony Counter and only those plates containing 30-300 colonies were used in the analyses. The counts were determined by multiplying the number of colonies counted by the reciprocal of the serial dilution. The plate counts, which represent a mean value for each station, are given in Table 33. Bacterial populations of the magnitude of 10^4 - 10^5 are average for rivers. Results from this study showed that the bacterial levels were between 10^4 - 10^5 in this area of the Trinity River.

The predominant genera for each station are also shown in Table 33. This report is not to be interpreted that these are the only microorganisms to be found at these stations. It simply means that, in the analysis by the investigator, the greatest quantity of the isolated organisms were included in the genera that are listed. Similar findings were observed in another study on a different section of the Trinity River (Silvey, et al., unpublished data).

In conclusion, the overall quality of the water in the Qubrey Reservoir should ultimately be higher than that in Garza-Little Elm Reservoir. This assumption is based mainly on the fact that the waste effluent from Gainesville will be substantially improved. Also, the pollution load that will be received by the Aubrey Reservoir is expected to be considerably less than that received by Garza-Little Elm reservoir presently.

Table 29. Results of chemical analyses on Aubrey Watershed Area.

| Station | DO* | BOD* | pH | Tot. Solids* | PO ₄ -P* | Iron* | Calcium* |
|----------|---------|-------|-----------|--------------|---------------------|-----------|------------|
| I-35 | 7.0-0.4 | 10-25 | 7.93-8.25 | 414-488 | 0.030-0.09 | Tr.-0.06 | 75.0-86.0 |
| GE | 3.5-6.7 | 20-35 | 7.60-8.05 | 484-544 | 0.69 -2.24 | 0.04-0.17 | 62.9-80.3 |
| Elm Fork | 6.4-8.0 | 5-9 | 7.90-8.00 | 455-607 | 0.23 -1.18 | 0.04-0.32 | 58.4-96.3 |
| duB | 6.5-8.2 | 3-8 | 7.60-8.02 | 578-1210 | 0.01 -0.03 | 0.08-0.36 | 49.3-151.6 |

* Expressed as mg/l (ppm).

Table 29 (continued from above).

| Station | Tot. C* | In.C* | Or. C* | NH ₄ -N* | NO ₃ -N* | NO ₂ -N* | Sp. Cond. |
|----------|---------|-------|--------|---------------------|---------------------|---------------------|-----------|
| I-35 | 52-66 | 44-53 | 6-15 | 0.03-0.21 | Tr.-0.54 | 0 -0.05 | 438-695 |
| GE | 70-88 | 49-67 | 16-26 | 1.42-3.20 | 0.02-0.56 | 0.05-0.2 | 510-773 |
| Elm Fork | 54-81 | 33-69 | 10-21 | 0.04-1.49 | 0.90-1.78 | 0.02-0.36 | 485-781 |
| duB | 40-68 | 20-59 | 9-20 | 0.02-0.50 | 0.06-0.39 | 0 -0.09 | 460-1512 |

* Expressed as mg/l (ppm).

Table 30. Total coliform and fecal coliform MPN mean values.

| Station | Total Coliforms | % | Fecal Coliforms | % |
|----------|-------------------|--------|-------------------|-------|
| I-35 | 6.3×10^5 | (98.6) | 8.8×10^3 | (1.4) |
| GE | 0.6×10^4 | (97.6) | 2.3×10^3 | (2.4) |
| Elm Fork | 1.0×10^4 | (83.0) | 1.7×10^3 | (17) |
| du Bois | 1.5×10^3 | (86.0) | 2.1×10^2 | (14) |

Counts expressed as organisms per 100 ml.

Table 31. Coliform types isolated from brilliant green lactose bile broth and EC broth and identified by IMViC Reactions*

| Coliform Type | No. Strains | Percent of Isolates |
|---------------|-------------|---------------------|
| ++-- | 30 | 50 |
| --++ | 20 | 33 |
| -+-- | 6 | 10 |
| +--- | 3 | 5 |
| ---+ | 1 | 2 |
| Total | 60 | 100 |

*IMViC battery of tests includes the following biochemical tests: Indole production, Acid Production (Methyl Red), Acetylmethyl carbinol production, and utilization of Citrate as sole carbon source.

Table 32. Enterococci mean counts.

| Station | Enterococci/100ml | Fecal Coliforms/100ml | FC/FS Ratio |
|----------|-------------------|-----------------------|-------------|
| I-35 | 3.3×10^2 | 8.8×10^3 | 26.6 |
| GE | 5.0×10^2 | 2.3×10^3 | 4.6 |
| Elm Fork | 3.0×10^2 | 1.7×10^3 | 5.6 |
| du Bois | 1.5×10^2 | 2.1×10^2 | 1.4 |

Table 33. Average total plate counts* and predominant genera of each station.

| Station | Average Plate Count | Predominant Genera |
|----------|---------------------|--|
| I-35 | 5.0×10^4 | <u>Enterobacter</u> , <u>Escherichia</u> , <u>Flavobacterium</u> |
| GE | 2.0×10^5 | <u>Escherichia</u> , <u>Enterobacter</u> , <u>Bacillus</u> , <u>Proteus</u> |
| Elm Fork | 5.6×10^4 | <u>Flavobacterium</u> , <u>Bacillus</u> , <u>Alkaligenes</u> , <u>Micrococcus</u> |
| du Bois | 4.2×10^4 | <u>Bacillus</u> , <u>Enterobacter</u> , <u>Flavobacterium</u> |

* Plate counts are expressed as organisms per ml.

Demographical-Economical-Cultural Elements

In an environmental impact study, man is the most dynamic factor. Many problems and plans of present land use and changes in land use have meaning only in terms of man and his cultural elements. Man and cultural factors must include man as the moving force and the environment he creates. Man's effect on the surface of the proposed reservoir site and adjacent areas increases as his numbers multiply. But, the numbers of people and their distribution is only one of the variables important to the study. Cultural phenomena associated with the area are not just the material things built, but the culture of people is also social, political, and economic processes and ideas, attitudes, values and objectives. Therefore, it is necessary to have effective knowledge and evaluation of man and cultural factors of the proposed Aubrey Reservoir site and situation. An inventory of the following types of existing characteristics and conditions of cultural elements have been obtained.

Demographic Elements

The study of population patterns as related to the Aubrey Reservoir Project will be examined spatially and temporally. Population data expressed for the project boundary area were obtained through interviews. That data reported outside of the project boundary was gathered from Bureau of the Census publications. The impact of the project will not be limited to those dwelling within the project boundary, but will extend outward in all directions. The initial impact will be on those who will have to move from their dwellings. With project use, waters will be supplied to the cities of Denton and Dallas. The reservoir will help to supplement recreation facilities of other reservoirs in north central Texas and possible some residences of south central Oklahoma. The entire project will be located in a rural area in parts of Cooke, Denton, and Grayson Counties.

There are no hamlets, villages, or towns and no clusters of population within the proposed project boundary.

Population Within Project Site

Dwelling within the proposed project boundary are 208 persons (spring 1972), creating a population density of 3.8 persons per square mile. Most of this population is concentrated in the southern two-thirds of the area, while the upper reaches of the site are almost void of population. The population age distribution comparison is expressed in Table 34.

Table 34. Population Age Distribution
Aubrey Reservoir Project Boundary Area

| Age Group | Number | Percent of Total |
|-----------|--------|------------------|
| Under 5 | 19 | 9.13 |
| 5-14 | 33 | 15.87 |
| 15-24 | 40 | 19.23 |
| 25-44 | 52 | 25.00 |
| 45-64 | 42 | 20.19 |
| 65-Over | 22 | 10.58 |
| Total | 208 | 100.00 |

There are 69 families living in the area. Of these families, 67 are White and 2 are Negro. There is a third Negro family living outside the area but adjacent to the project boundary.

The range in family size is one to eight with an average of 3.1 persons.

Residents living in the area have dwelled there for as short a time as one month to as long as 68 years. Approximately 65% of the families have lived in the area 10 years or less.

Table 35. Size of Families in Proposed Aubrey Reservoir Project Boundary.

| Number of People/Family | Number of Families* | % |
|-------------------------|---------------------|-------|
| 1 | 8 | 11.9 |
| 2 | 20 | 29.9 |
| 3 | 16 | 23.9 |
| 4 | 12 | 17.9 |
| 5 | 6 | 8.9 |
| 6 | 2 | 3.0 |
| 7 | 2 | 3.0 |
| 8 | 1 | 1.5 |
| Total | 67 | 100.0 |

*No data on 2 families

Table 36. Length of Time Families Have Lived in Proposed Aubrey Reservoir Area Boundary.

| Period of Years | Number of Families* | Percent |
|------------------|---------------------|---------|
| Less than 1 year | 7 | 11.00 |
| 1-5 | 20 | 31.75 |
| 6-10 | 14 | 22.20 |
| 11-15 | 6 | 9.50 |
| 16-20 | 1 | 1.60 |
| 21-25 | 2 | 3.17 |
| 26-30 | 1 | 1.60 |
| 31-35 | 2 | 3.18 |
| 36-40 | 2 | 3.18 |
| 41-45 | - | ---- |
| 46-50 | 2 | 3.18 |
| 51-55 | 1 | 1.60 |
| 56-60 | - | ---- |
| 61-65 | 2 | 3.18 |
| 66-70 | 3 | 4.80 |

*Data on years of residence was not obtained from 6 families.

County Subdivisions

The proposed project site will be located in four county subdivisions--the Gainesville southeast subdivision in Cooke County, the Pilot Point-Aubrey subdivision and the Sanger subdivision in Denton County, and southwest Grayson subdivision in Grayson County. Persons living in the county subdivisions are a part of the population within the reservoir site, and the others are living adjacent to and in the vicinity of the reservoir site. Within the four county subdivisions are 13,993 persons. The area has been increasing in population.

Table 37. Population - County Subdivisions.

| County Subdivisions | 1970 | 1960 | % Change |
|-----------------------|--------|------------------|----------|
| Gainesville Southeast | 1,162 | 1,291 | -10.0 |
| Pilot Point-Aubrey | 5,369 | 4,000 | 34.2 |
| Sanger | 3,838 | 3,154 | 21.7 |
| Southwest Grayson | 3,624 | No data reported | |
| Total | 13,993 | | |

Source: U. S. Bureau of Census (96).

Towns and Cities Near the Reservoir Site

More or less surrounding the proposed reservoir are eight towns and cities (Plate I). The population of these communities will be within a 15-minute drive of the reservoir. All of the communities show a growth in population.

Counties of North Central Texas

The proposed reservoir is to be located within parts of three counties--Cooke, Denton, and Grayson. These three counties have a total population (1970) of 182,329 persons. Each of these counties have continually increased in population. This total population is within less than one hour's drive to the reservoir site.

Table 38. Towns and Cities Near the Proposed Reservoir Site.

| Towns and Cities | Population | | Percent of Change |
|------------------|------------|--------|-------------------|
| | 1970 | 1960 | |
| Aubrey | 731 | 534 | 36.9 |
| Denton | 39,874 | 26,844 | 48.5 |
| Gainesville | 13,830 | 13,083 | 5.7 |
| Pilot Point | 1,663 | 1,254 | 32.6 |
| Sanger | 1,603 | 1,190 | 34.7 |
| Tioga | 456 | 403 | 13.2 |
| Valley View | NA | NA | NA |
| Whitesboro | 2,927 | 2,485 | 17.8 |

Other counties that are adjacent to the three in which the reservoir will be located are Collin, Dallas, Fannin, Montague, Tarrant, and Wise. Most of their population will be within one and one-half hour of the project. Only one county, Fannin, had a decrease in population from 1960 to 1970. The nine counties have a total population of 2,168,276 persons.

Table 39 reveals the rapid population growth occurring in north central Texas. Even though several other reservoirs exist in the area (Plate V) to serve the present population for water supply, flood control and recreation, the Aubrey Reservoir will supplement the present reservoir uses of a rapidly growing region.

Table 39. Counties of North Central Texas in which the Proposed Aubrey Reservoir is to be Located and the Adjacent Counties.

| Counties and Years | Total | Percent of Change |
|--------------------|--------|-------------------|
| ¹ Cooke | | |
| 1970 | 23,471 | 4.0 |
| 1960 | 22,560 | 1.9 |
| 1950 | 22,146 | - |

| <u>Counties and Years</u> | <u>Total</u> | <u>Percent of Change</u> |
|---------------------------|--------------|--------------------------|
| ¹ Denton | | |
| 1970 | 75,633 | 59.5 |
| 1960 | 47,432 | 14.7 |
| 1950 | 41,365 | - |
| ¹ Grayson | | |
| 1970 | 83,225 | 13.9 |
| 1960 | 73,043 | 3.7 |
| 1950 | 70,467 | - |
| ² Collin | | |
| 1970 | 66,920 | 62.2 |
| 1960 | 41,247 | -1.1 |
| 1950 | 41,692 | - |
| ² Dallas | | |
| 1970 | 1,327,321 | 39.5 |
| 1960 | 951,527 | 54.8 |
| 1950 | 614,799 | - |
| ² Fannin | | |
| 1970 | 22,705 | -4.9 |
| 1960 | 23,880 | -23.6 |
| 1950 | 31,253 | - |
| ² Montague | | |
| 1970 | 15,326 | 2.9 |
| 1960 | 14,893 | -12.8 |
| 1950 | 17,070 | - |
| ² Tarrant | | |
| 1970 | 716,317 | 33.0 |
| 1960 | 538,495 | 49.1 |
| 1950 | 361,253 | - |
| ² Wise | | |
| 1970 | 19,687 | 15.7 |
| 1960 | 17,012 | 5.4 |
| 1950 | 16,141 | - |

Source: U. S. Bureau of Census (96,97)

¹Counties in which Aubrey Reservoir will be located

²Adjacent Counties

Within a part of these counties are portions of three Standard Metropolitan Statistical Areas (SMSA). These are Denison-Sherman (SMSA) in Grayson County, Dallas (SMSA) in Dallas, Denton, and Collin Counties, and Fort Worth (SMSA) in Tarrant County.

Ethnic Composition

The population dwelling within the proposed reservoir site is predominantly White-Anglo-Saxon-Protestant. Only two Negro families live within the project site. There are no Indians, Mexican-American, or people of Asian ancestry. In this area there are no tightly knit groups of common traits and customs.

Employment

The proposed reservoir site does not provide full employment opportunities for all those residing in the area. As a result of the survey, only 32.84% have full employment in this area, while 31.35% have only a part of their employment within the reservoir and 35.64% have no employment there. Of the 22 persons having full employment in the reservoir site, 19 are engaged in full-time agriculture, 2 in part-time agriculture in the reservoir site with the balance of their employment outside the area. Nineteen of the 21 receive 25% or less of their income from employment in the reservoir site. Then, there are 24 who live in the area but have no employment within the reservoir site. Five of the 24 are retired and 19 commute to jobs outside the area. They commute to Sanger, Pilot Point, Aubrey, Denton, Lewisville, Dallas, and Fort Worth. Some of the commuters travel as much as 50, 60, and 70 miles to their place of employment.

Housing

Based on the field survey, there are approximately 280 buildings within the proposed reservoir boundary. This includes houses, barns, and storage buildings. There are 63 houses and 6 mobile homes presently being lived in.

Vacant and abandoned houses total 35. The houses are dispersed across the landscape to give a scattered appearance. Only in a few places does there exist 3 or 4 houses close enough to each other to give a cluster appearance. Approximately 75% of the houses are constructed of wood siding and painted, 17% are brick or brick and wood, 7% are of stone, and 3% have asbestos siding. Based on numbers of rooms, 12% have 4 rooms, 35% have 5 rooms, 28% have 6 rooms, 12% have 7 rooms, and 13% more than 7 rooms. In a judgement as to the condition of the houses, general categories of good, average, and poor conditions were designated. Based on these categories, 45% are considered to be in good condition, 32% average, and 23% in poor condition. Another judgement value was made as to the estimated value of the houses. This judgement does not include any other buildings or the land on which the house is located. The following categories were designated and, based on the estimated values, percentage for each category calculated:

| | |
|--------------------|-------|
| less than \$10,000 | 68.4% |
| 10,000 - 14,999 | 14.0% |
| 15,000 - 19,999 | 8.8% |
| 20,000 - 24,999 | 5.3% |
| 25,000 - 34,999 | 3.5% |

Modern facilities do not exist at all houses. One family did not have a TV set, and 13 did not have a telephone. There are 4 houses without hot running water, flush toilet, bathtub or shower and complete modern kitchen facilities. One house has no running cold water.

Tenure Structure

Due to insufficient time, tenure information is incomplete. Based on the data collected, 19 families rent the house in which they live, and only 4 of these families are engaged in agriculture in the area. There are 48 families that would be classed as owner occupied; that is, dwelling on the land they own. There appeared to be 5 of the dwellings that are used occasionally, such as on weekends. Some farms are operated by owners who do not live on the land but reside in nearby communities, such as Denton and Pilot Point. Data has not been collected on extensive this practice is in the area.

Income and Taxes

Income data are difficult or impossible to obtain. With the use of a questionnaire which the family could return by mail with no name, 37 families were willing to report a range of their annual gross income. Most families reported an income between \$5,000 to \$9,999.

Table 40. Annual Gross Income Based on 37 Families Dwelling in Proposed Aubrey Reservoir Site.

| Range of Annual Gross Income | Percent of Families |
|------------------------------|---------------------|
| Less than \$5,000 | 22 |
| 5,000 - 9,999 | 43 |
| 10,000 - 14,999 | 16 |
| 15,000 - 19,999 | 3 |
| 20,000 - 24,999 | 8 |
| 25,000 or Over | 8 |

Time was not sufficient to collect data from school districts and counties as to the total amount of taxes that would be lost by removing the lands within the project from tax rolls. Based on tax data reported by 28 families living in the area, they paid a total of \$7,770.12 in school, county, and state taxes on their property. From information received from some of these people an attempt was made to calculate taxes paid on property. It is estimated to be approximately \$95,000. These tax money losses will be temporary, because once the reservoir is completed there will be a great increase in house construction on sites adjacent to the project which will probably bring in more tax monies than presently collected from the area. There are additional monies returned to the local area from recreational leases.

Economical Elements

Industry is comprised of distinct groups of productive enterprise. Through these one has employment opportunities to economically support himself and family. The proposed

Aubrey Reservoir Project area is 100 percent rural (based on the Bureau of Census' definition of rural) and the kinds of industrial groups are those generally associated with rural areas. Data on types of industries existing in the area are based on observation in the field and interviews with those living and working in the area.

The major industrial divisions existing in the proposed reservoir site are plant and animal, mining, contract construction, commerce, service, and manufacturing (classification based on the Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, U. S. Government Printing Office, Washington, D. C., 1957, 98).

The plant and animal industries include the major groups of agriculture and forestry. Agricultural operation consists of the production of domesticated plants and animals. Within the proposed reservoir there presently exist: cropland (3,861 acres), old field (26,635 acres), and forest (4,554 acres) (Plate III). All of the old field and forest lands are presently or recently used for grazing livestock. Forestry operation is limited to cutting firewood, digging and balling of native trees for landscaping, and production of pecans.

Mining industry is the extraction of economic minerals occurring in the area. It includes quarrying and well operation. Within the area exist Jacobs oil field, sand and gravel quarries, and quarrying of some topsoil.

Contract construction refers to the construction of new works, additions, alterations, and repair of immobile structures. This includes the construction of houses, farm buildings, roads, bridges, railroads, farm ponds, well drilling, telephone lines, transmission lines, and pipelines in the area.

Commerce industries are those establishments primarily engaged in facilitating the ownership transfer of property. Within the reservoir site is a salvage yard and an antique shop.

Service industries are those establishments primarily engaged in providing benefits that are directed towards the buyer's person or property. There exist one automotive repair shop, one welding shop, an American Legion hut, one church, a baseball camp for boys, and a retreat.

Manufacturing industries give form utility to raw materials. The only manufacturing is associated with the welding establishment. The owner-operator does manufacture some items used in rural areas, such as steel gates and livestock feeders.

Although several industrial groups are present in the area, most of them exist in limited numbers and size of operation. The most extensive industry is the agricultural portion of the plant and animal industrial group. This would be followed by contract construction and mining industries.

Other Cultural Elements

Other cultural elements in the reservoir site are roads, railroads, utilities, and farm ponds. The area is well served with a network of public roads. Most are surfaced with natural materials of sand and gravel and maintained by the counties. There are only 11 miles of hard surfaced farm-to-market roads in the area and one U. S. highway crossing two arms of the reservoir. One railroad extends across parts of the eastern portion of the proposed site. The entire reservoir area is served by a network of telephone lines and rural electrification lines. Television and radio reception is available to the entire area. Farm ponds, built by man, are prominent features across the landscape.

Conclusion

There is a tendency among some to take present land use as something fixed in an area, whereas it may be far below the potential land use because of social and economic factors outside of the land. Concentration on present land use should not prejudice the development of plans for a higher potential use and production. Human population needs to evaluate the potential of its inhabited area and to organize its life about the natural environment in terms of developed skills and tools available and in the boundaries of values which people accept.

Modern cultural development within the proposed reservoir area is evidence of man's ability to change the original landscape--landforms, vegetation, and other natural attributes. Thus the physical and cultural environment as altered by man is a major concern of an impact study.

GENERAL RECOMMENDATIONS

Numerous specific recommendations appear in the reports on parameters and elements. The following are several of our general recommendations:

1. We recommend that the U.S. Army Corps of Engineers set aside a portion of the land adjacent to the proposed reservoir as a natural preserve and field study site. The Eastern Cross Timbers area is a unique example of a finger of forest jutting into a prairie ecosystem as a result of edaphic variations. Much of the Cross Timbers area has been destroyed by cutting, burning, and construction activities.

Therefore, we believe it would be in public interest to preserve a remnant of this unique vegetation type for future study by specialists and enjoyment by the public. The Department of Biological Sciences and the Institute for Environmental Studies at North Texas State University have personnel who are deeply interested in preserving such a site and who are eminently qualified to conduct scientific investigations on the site.

We are particularly interested in establishing a base from which we may conduct long-term studies on the actual impact of the proposed reservoir (during both construction and use periods) on the environment of the area. We anticipate that the results of such long-term studies may be compared with our predictions in the first segment of this report. A direct comparison of the predicted and observed impacts would provide the most powerful evaluation of the Battelle EES. Results from these studies would be quite valuable to the Army Corps of Engineers.

2. We recommend the following with respect to the applications of the Battelle-Columbus EES:

- a. That the construction and use period environmental impacts be calculated separately as detailed in an example in the Sport Fish parameter report. This method of calculation makes the system much more sensitive to environmental impairment during the construction period.

- b. That the anticipated change in environmental quality without the project be incorporated into the calculations. Since the quality of the environment may increase or decrease without the project, it is important to assess the impacts of the construction and use periods on a future environment whose quality may differ from the present.
- c. That some means of entering public opinion and concern for the environment into the Battelle EES be established. This might take the form of public hearings held in the area of the project. Invitations to such hearings should be extended to all interested citizens, but particularly to environmental action groups, conservation and sportsman's organizations, and agricultural interest groups.
- d. That the advice and counsel of personnel of local, state, and federal governmental agencies concerned with environmental impacts be actively sought after. These individuals should also be involved in the review of parameter reports in their areas of expertise before the final report is submitted.
- e. That parameters which are basically important only to the Bureau of Reclamation's projects in the western states be replaced by ones relevant to the geographic region within which the impact is being studied. Those parameters which have importance in many regions should be weighted according to their relative significance within each region. We suggest different sets of parameters and weights for different regions.
- f. That the Army Corps of Engineers initiate a project to develop a version of the EES which is "tailored" to the Trinity River Basin.
- g. That in the future environmental impact studies on projects of this magnitude be contracted for at least 12 months before the completion deadline. The Aubrey Reservoir impact statement was completed in approximately 3 months. Most of the parameters included in the Battelle EES should be measured and averaged over at least 1 year before the data are entered into the worksheet matrices.

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APPENDIX A
VALUE FUNCTION GRAPHS

A-1

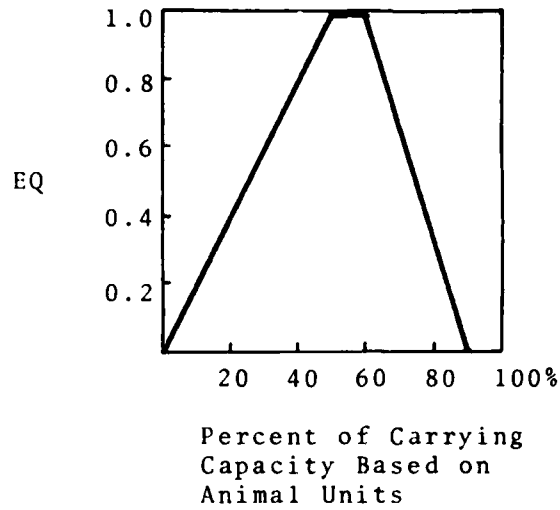


FIGURE 1. BROWSERS AND GRAZERS

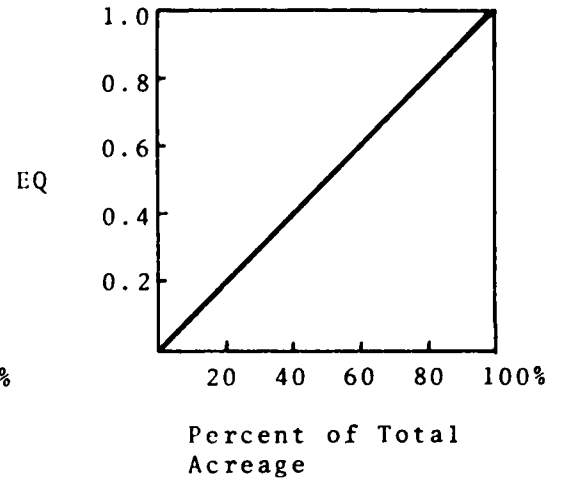


FIGURE 2. CROPS

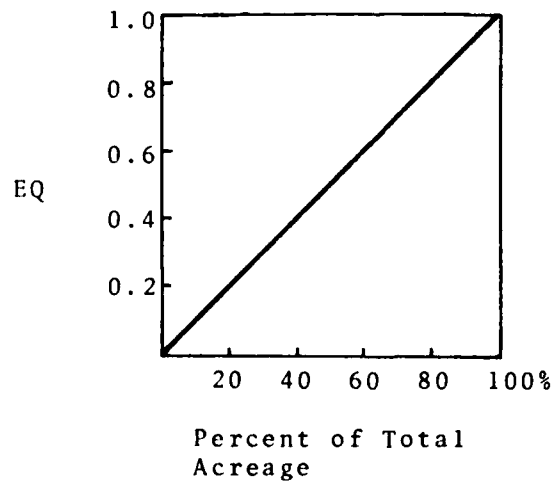


FIGURE 3. NATURAL VEGETATION

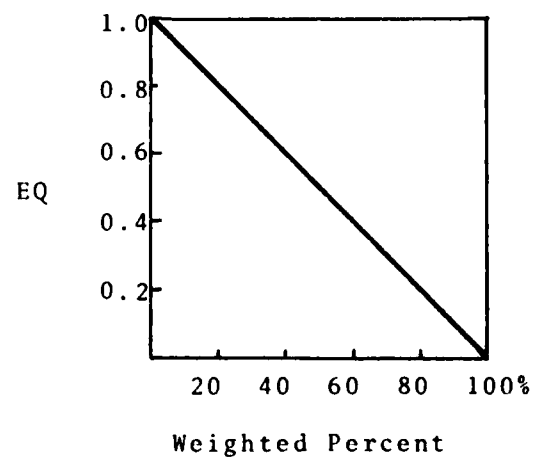


FIGURE 4. PEST SPECIES

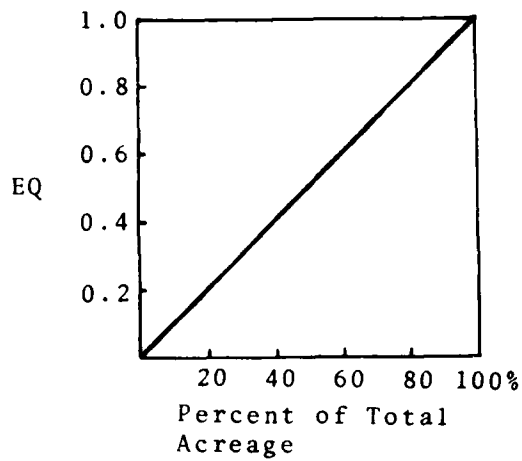


FIGURE 5. UPLAND GAME BIRDS

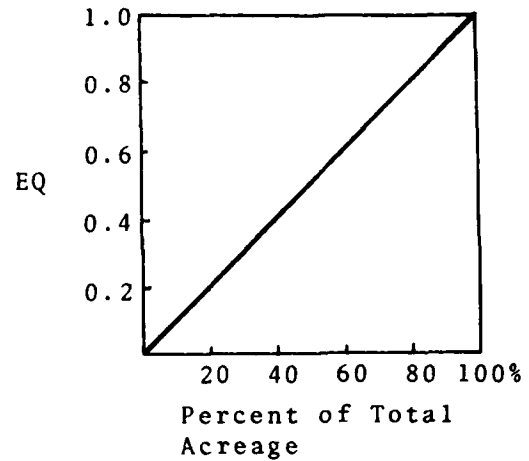


FIGURE 6. COMMERCIAL FISHERIES

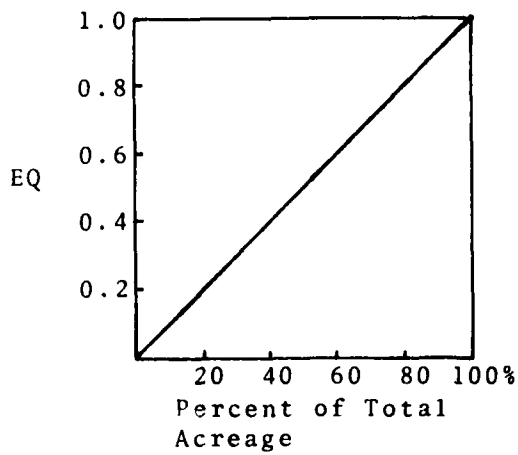


FIGURE 7. NATURAL VEGETATION

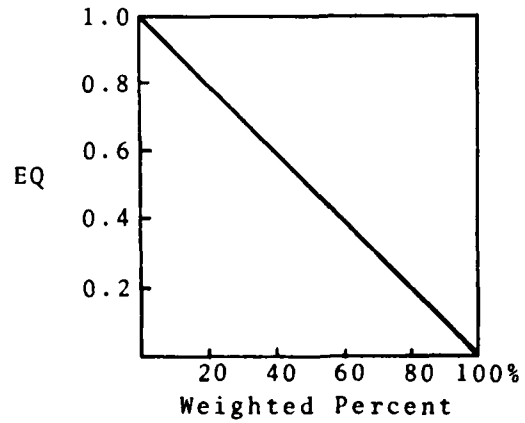


FIGURE 8. PEST SPECIES

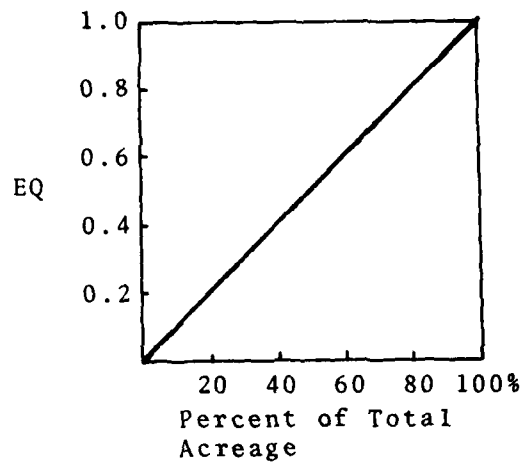


FIGURE 9. SPORT FISH

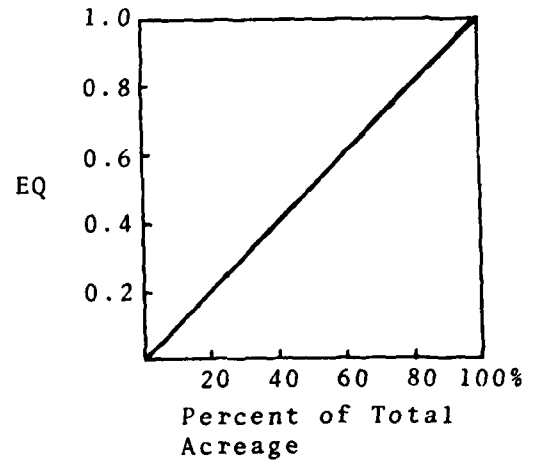


FIGURE 10. WATERFOWL

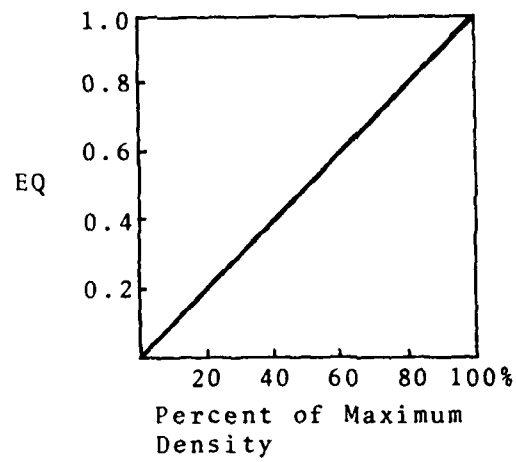


FIGURE 11. FOOD WEB INDEX

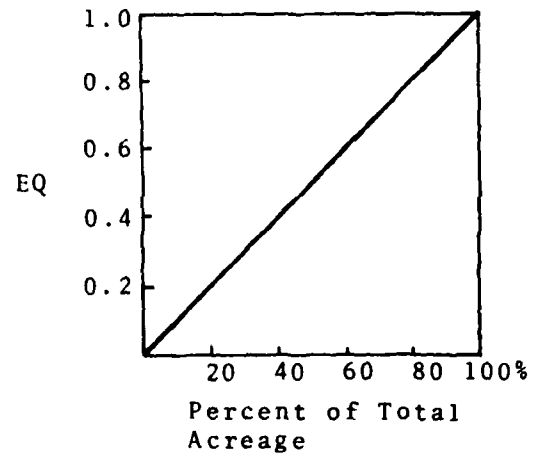


FIGURE 12. LAND USE

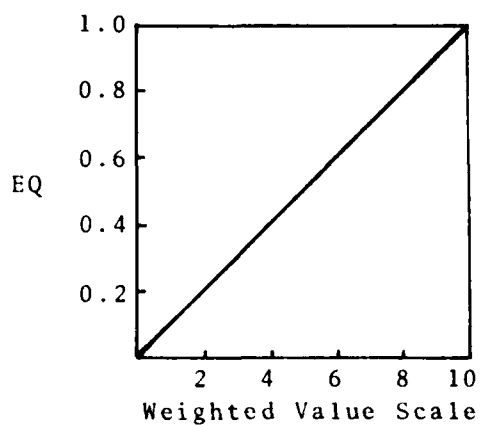


FIGURE 13. RARE AND ENDANGERED SPECIES

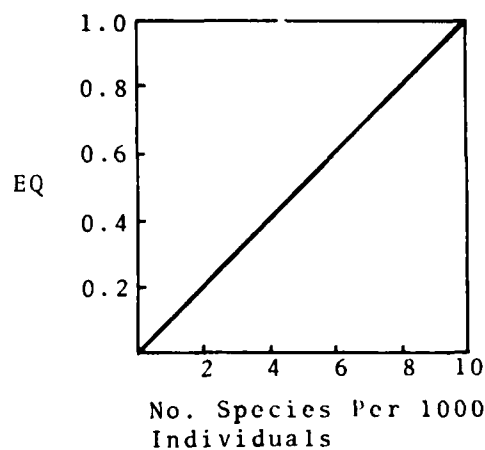


FIGURE 14. SPECIES DIVERSITY

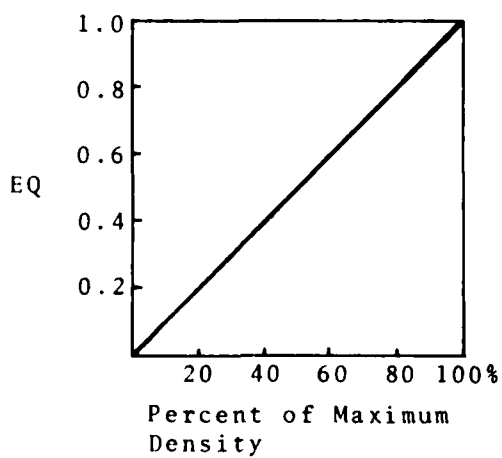


FIGURE 15. FOOD WEB INDEX

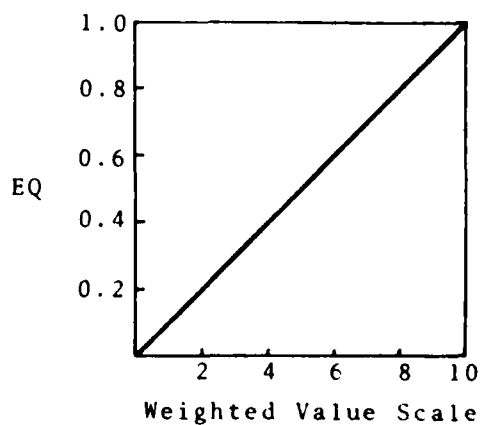


FIGURE 16. RARE AND ENDANGERED SPECIES

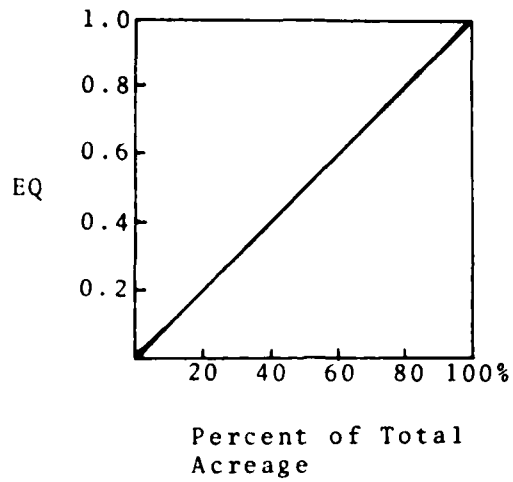


FIGURE 17. RIVER CHARACTERISTICS

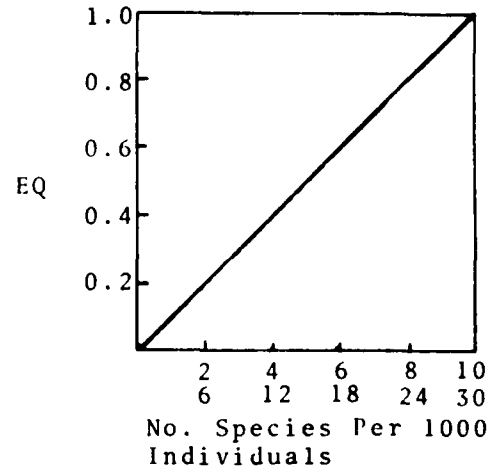


FIGURE 18. SPECIES DIVERSITY

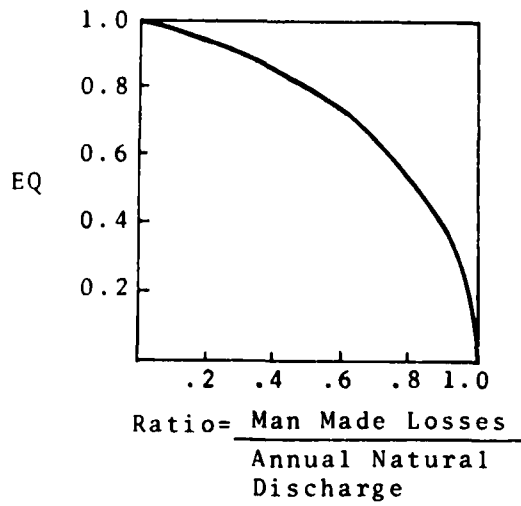


FIGURE 19. BASIN HYDROLOGIC LOSS

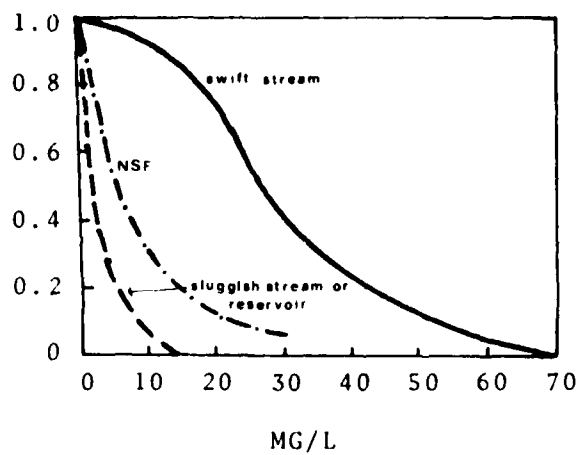


FIGURE 20. BOD

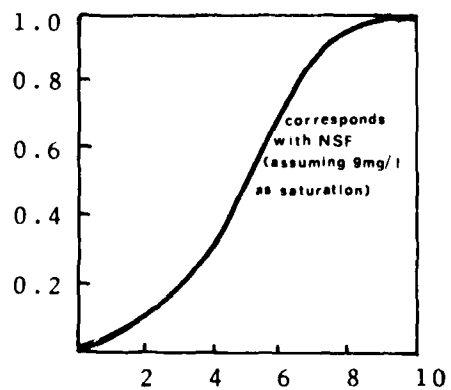


FIGURE 21. DISSOLVED OXYGEN

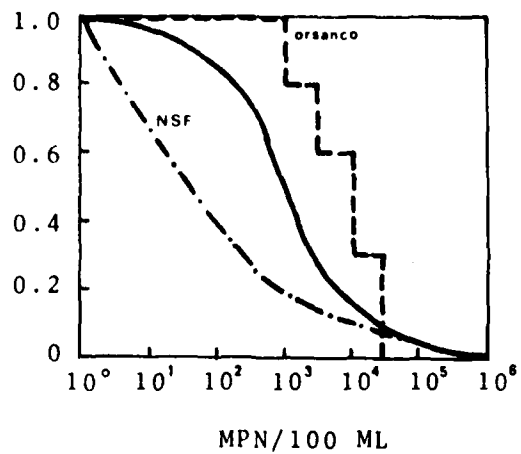


FIGURE 22. FECAL COLIFORMS

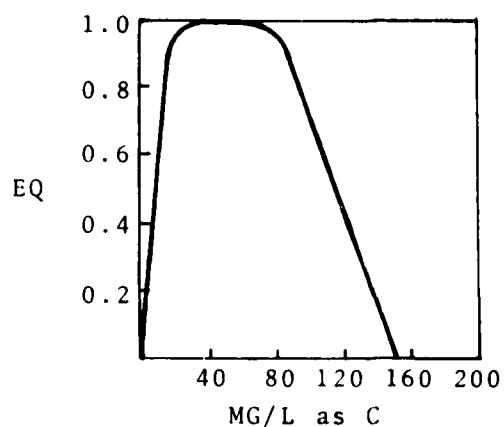


FIGURE 23. INORGANIC CARBON

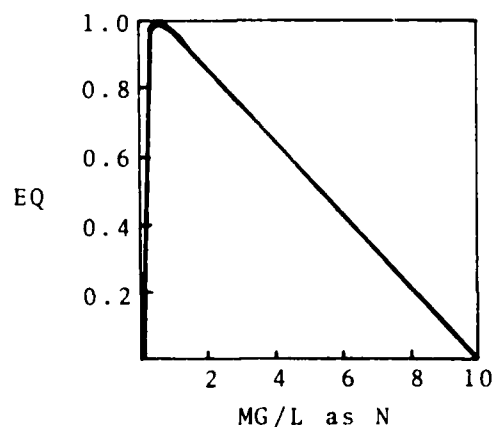
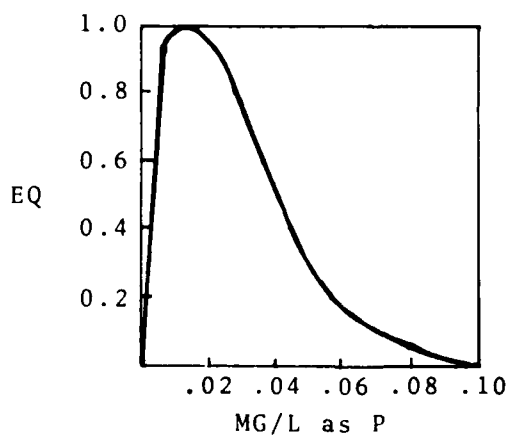
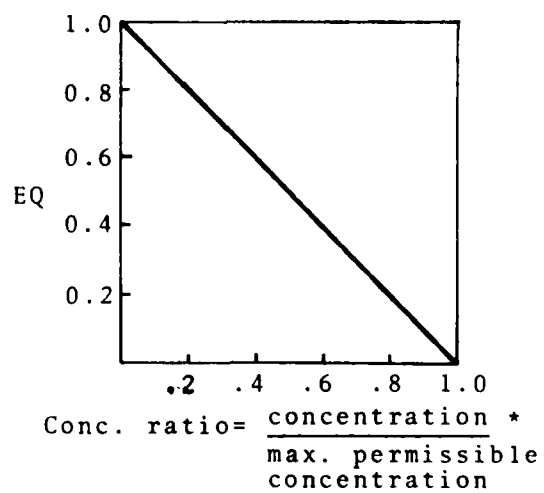


FIGURE 24. INORGANIC NITROGEN

FIGURE 25. INORGANIC
PHOSPHATE (PO₄)

*see Pesticide report

FIGURE 26. PESTICIDES

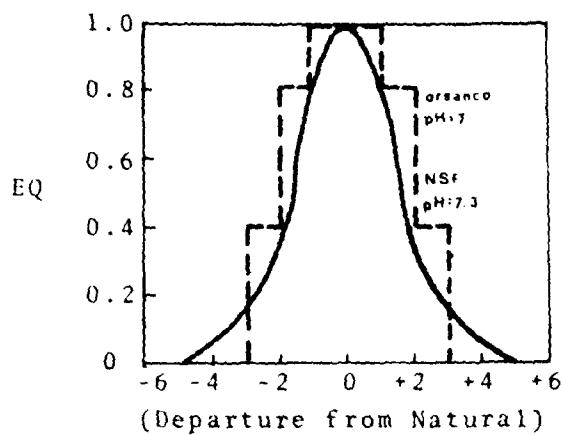
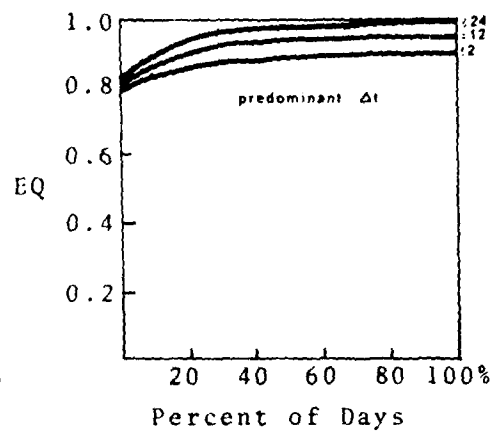
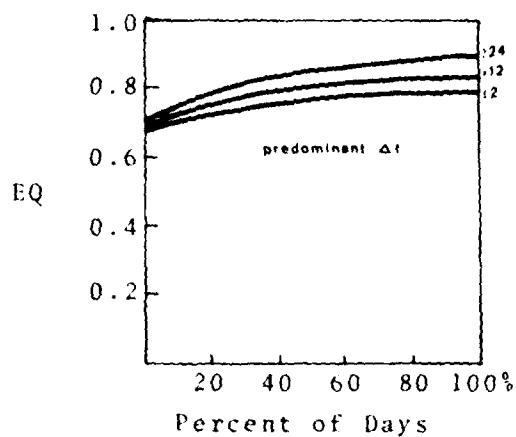
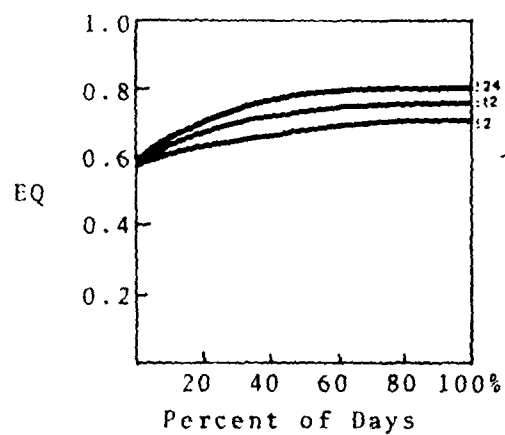


FIGURE 27. pH

FIGURE 28. STREAM FLOW
VARIATIONS, DAILY MAX/
MIN \leq 2:1FIGURE 29. STREAM FLOW
VARIATIONS, DAILY MAX/
MIN \leq 10:1FIGURE 30. STREAM FLOW
VARIATIONS, MAX/MIN
 \leq 50:1

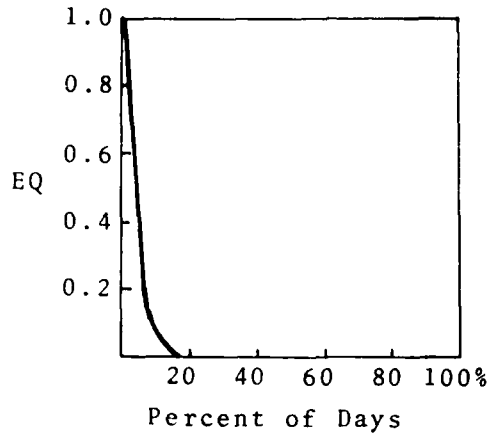


FIGURE 31. STREAM FLOW VARIATIONS, MAX/MIN > 50:1

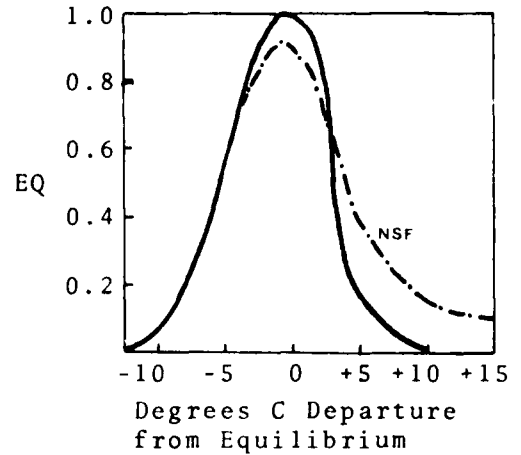


FIGURE 32. TEMPERATURE

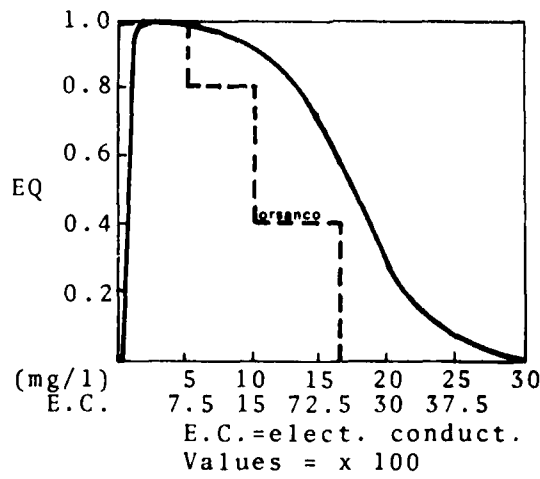


FIGURE 33. TOTAL DISSOLVED SOLIDS

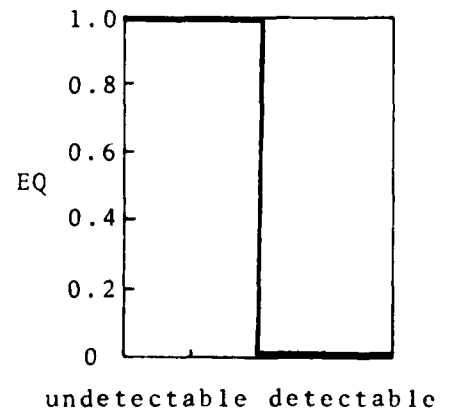


FIGURE 34. TOXIC SUBSTANCES

A-10

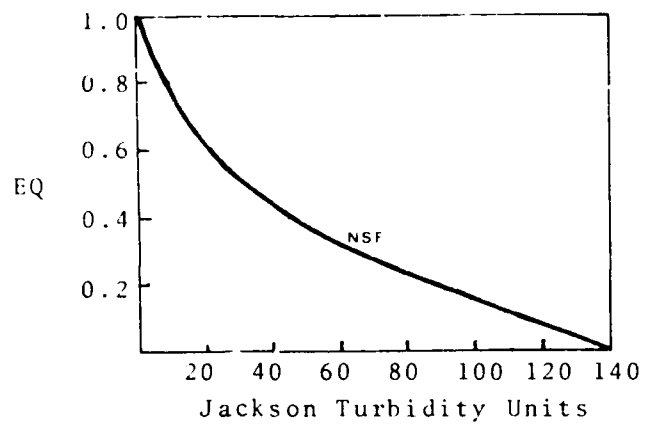


FIGURE 35. TURBIDITY

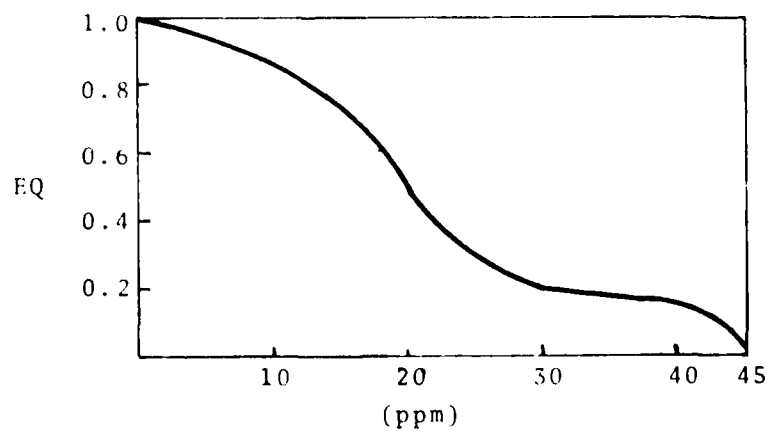


FIGURE 36. CARBON MONOXIDE

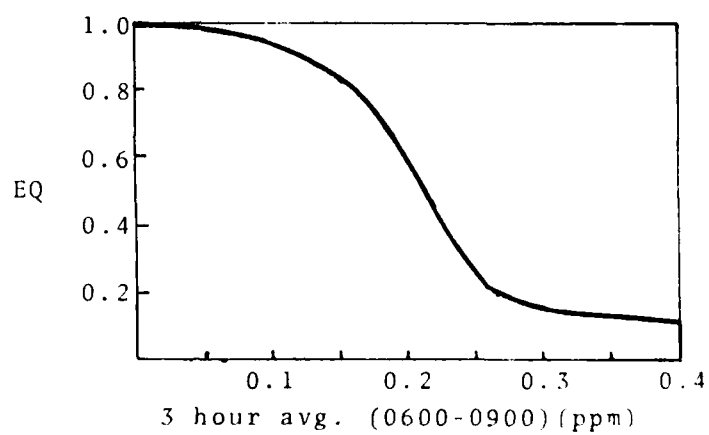


FIGURE 37. HYDROCARBONS

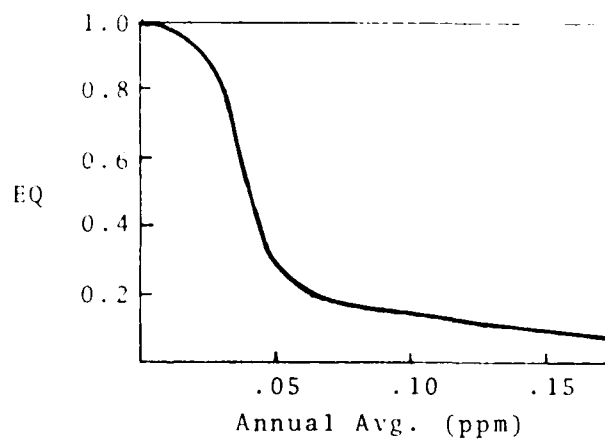


FIGURE 38. NITROGEN OXIDES

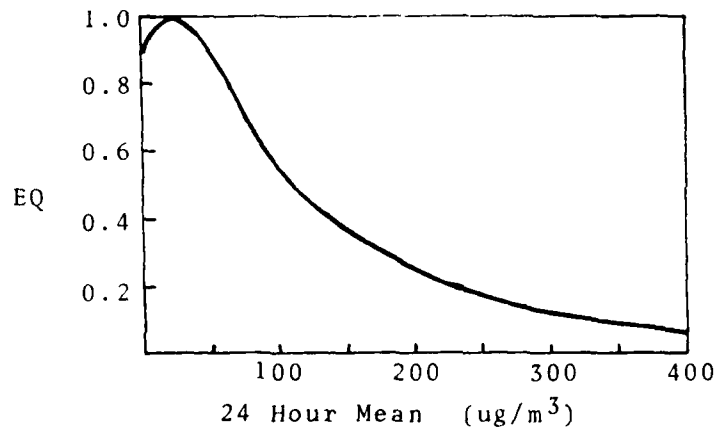


FIGURE 39. PARTICULATE MATTER

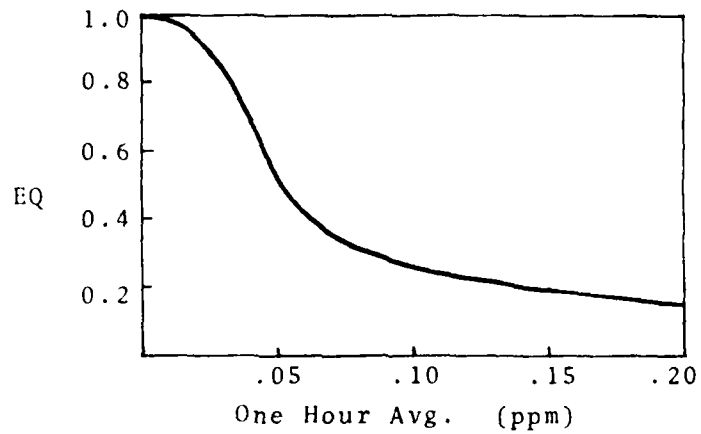


FIGURE 40. PHOTOCHEMICAL OXIDANTS

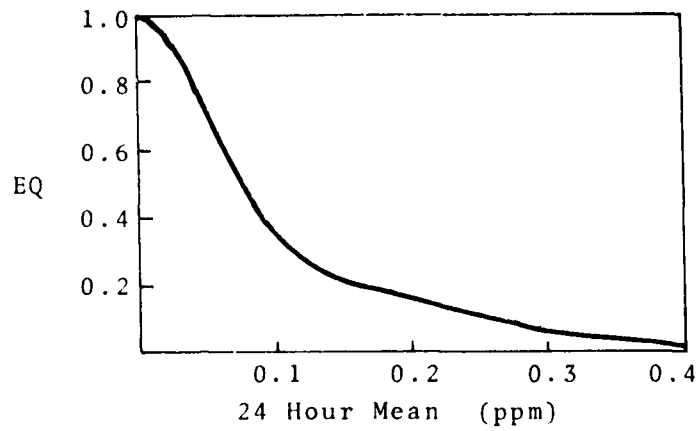


FIGURE 41. SULFUR OXIDES

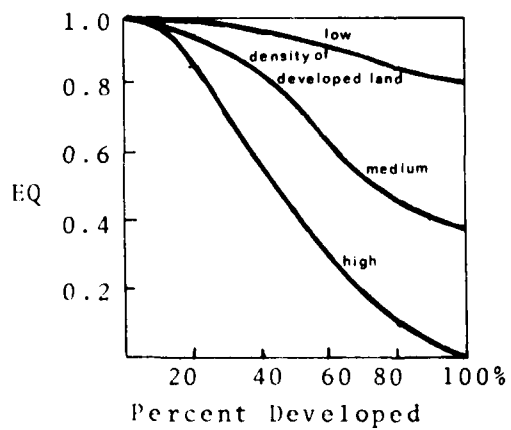


FIGURE 42. LAND USE

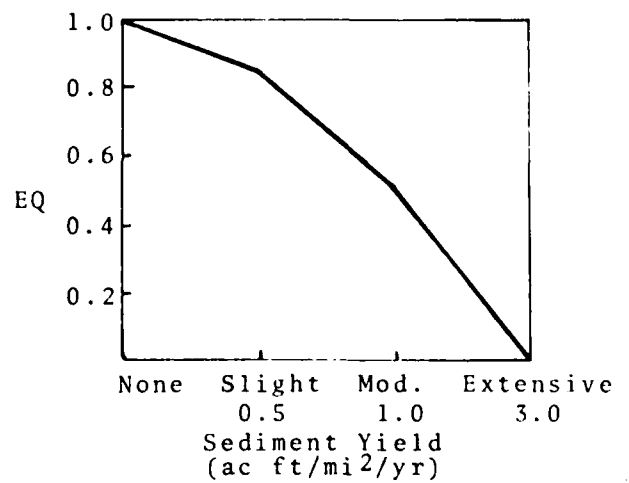


FIGURE 43. SOIL EROSION

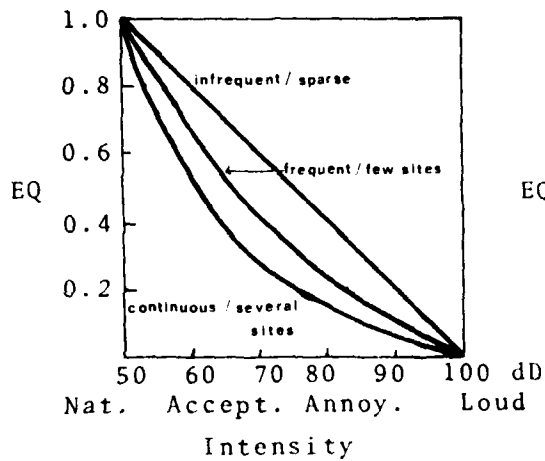


FIGURE 44. NOISE

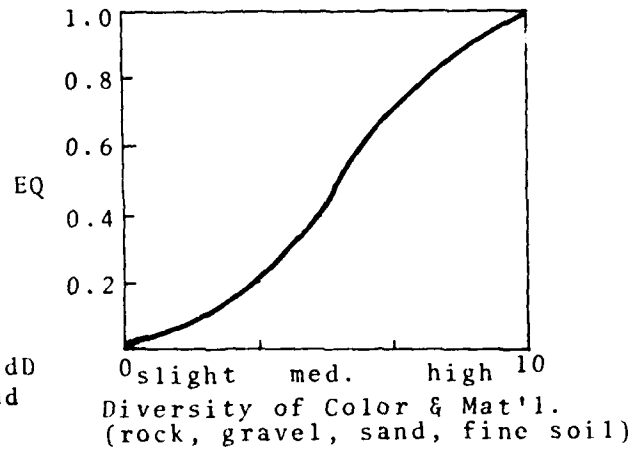


FIGURE 45. GEOLOGIC SURFACE MATERIAL

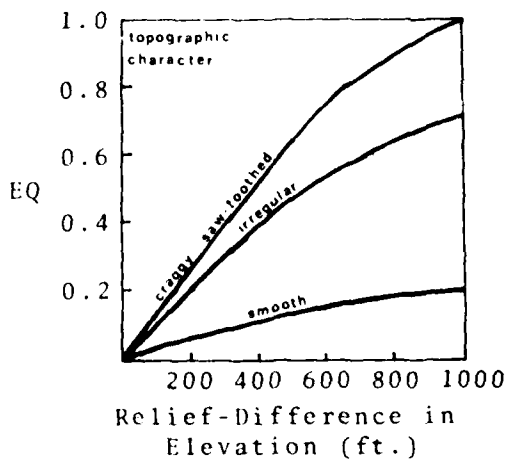


FIGURE 46. RELIEF AND TOPOGRAPHIC CHARACTER

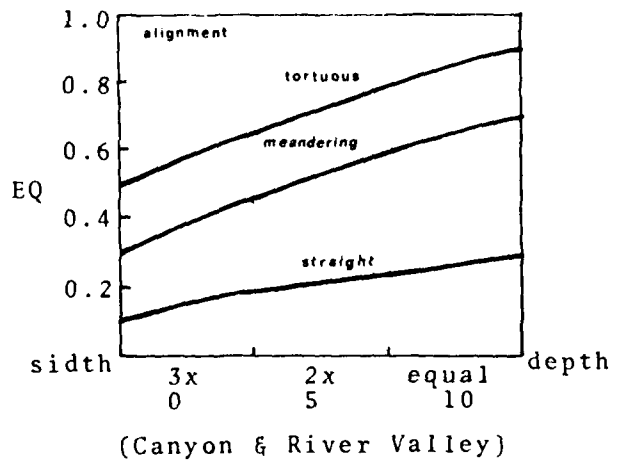


FIGURE 47. WIDTH AND ALIGNMENT

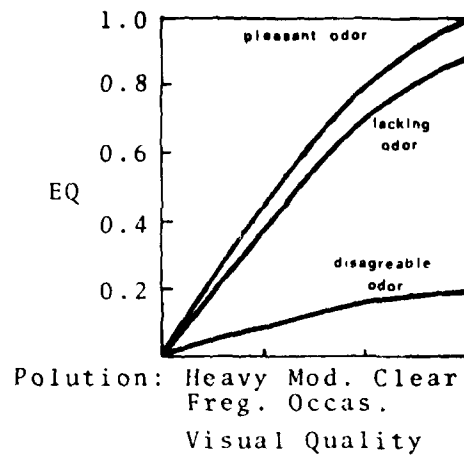


FIGURE 48. ODOR AND VISUAL QUALITY

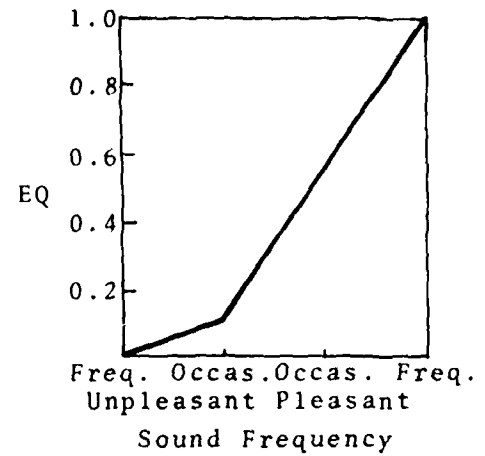


FIGURE 49. SOUNDS

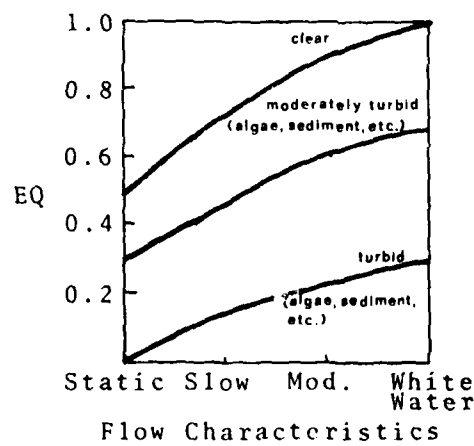


FIGURE 50. APPEARANCE OF WATER

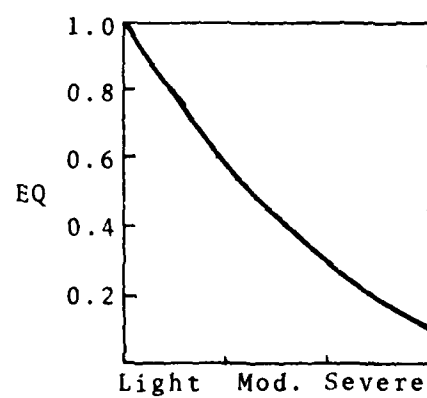


FIGURE 51. LAND AND WATER INTERFACE

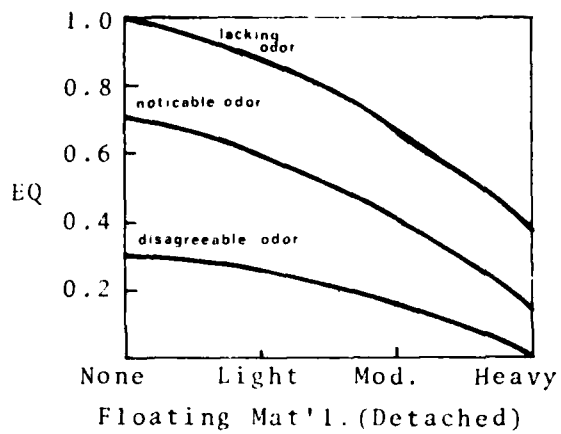


FIGURE 52. ODOR AND FLOATING MATERIALS

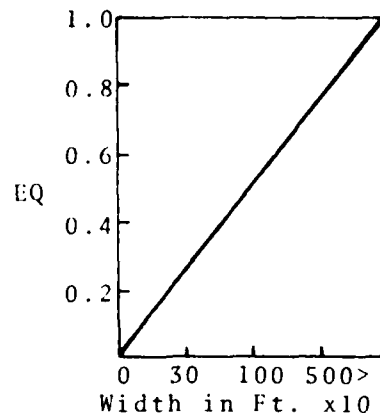


FIGURE 53. WATER SURFACE AREA

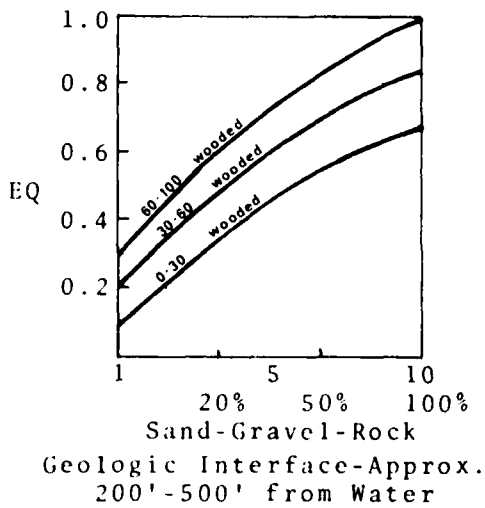


FIGURE 54. WOODED AND GEOLOGIC SHORELINE

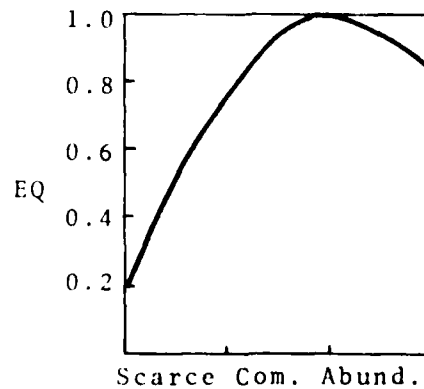


FIGURE 55. ANIMALS-DOMESTIC

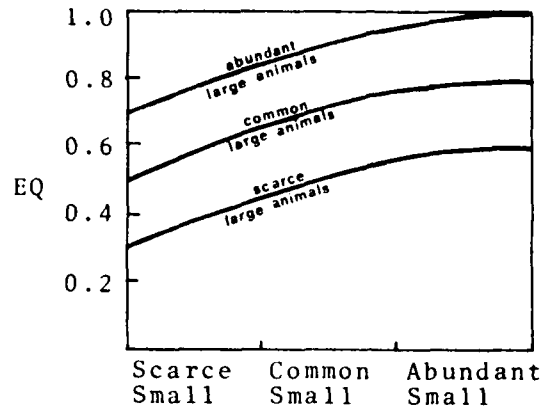


FIGURE 56. ANIMALS-WILD

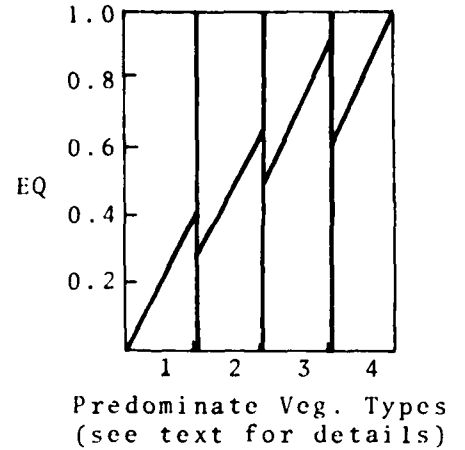


FIGURE 57. DIVERSITY OF VEGETATION TYPES

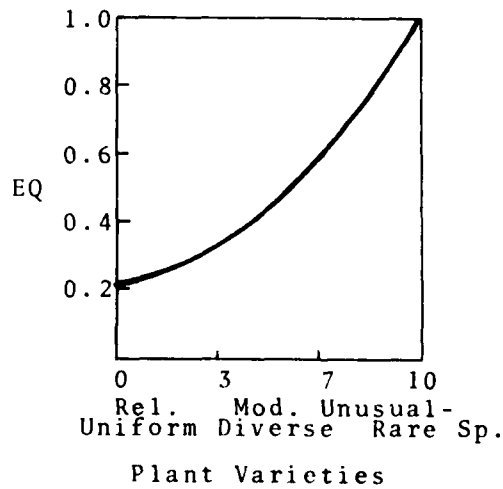


FIGURE 58. VARIETY WITHIN VEGETATION TYPES

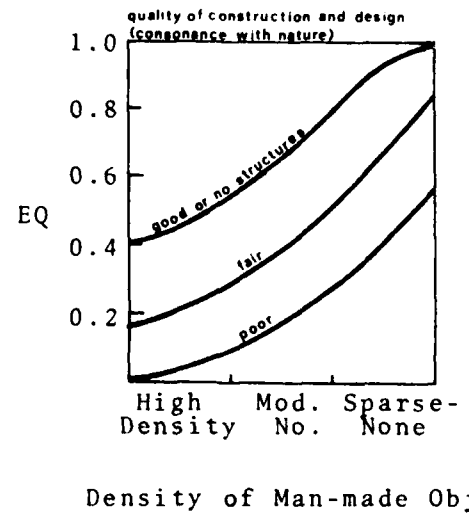


FIGURE 59. MAN-MADE OBJECTS

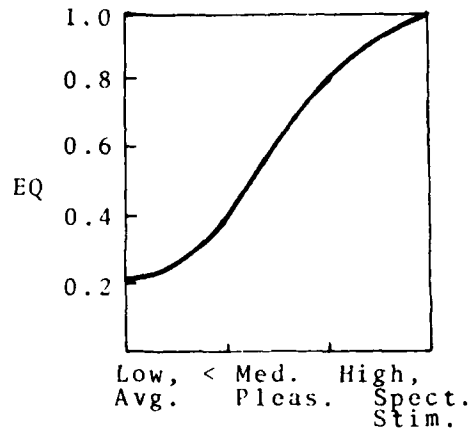


FIGURE 60. COMPOSITE EFFECT

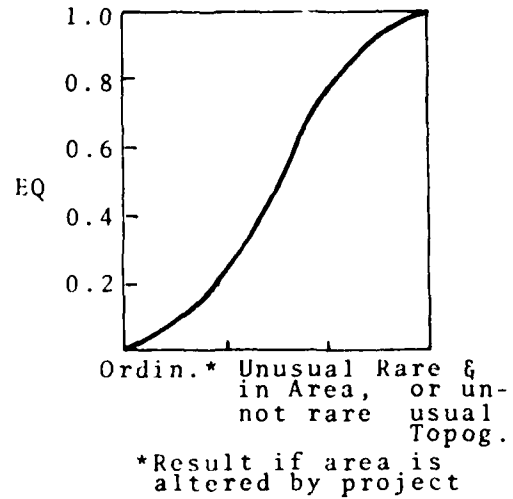


FIGURE 61. UNIQUE COMPOSITION

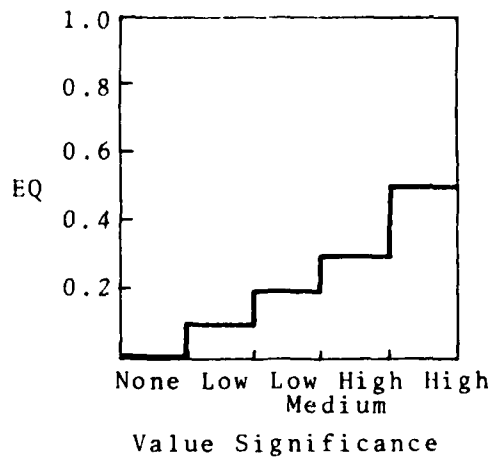


FIGURE 62. EDUCATIONAL/SCIENTIFIC
INTERNAL PACKAGES

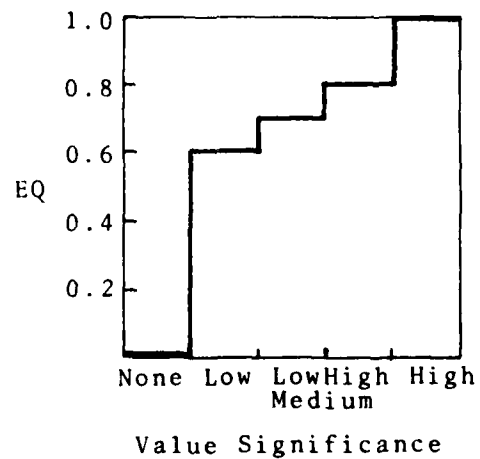


FIGURE 63. EDUCATIONAL/SCIENTIFIC
EXTERNAL PACKAGES

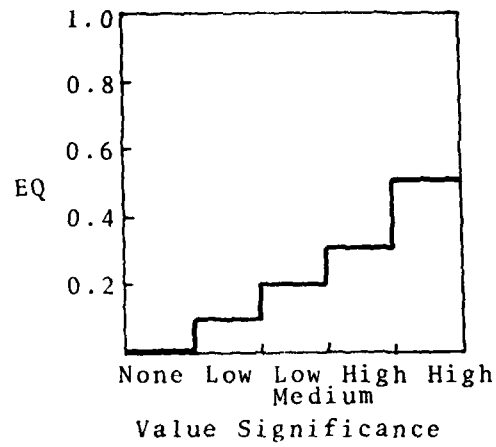


FIGURE 64. HISTORICAL INTERNAL PACKAGES

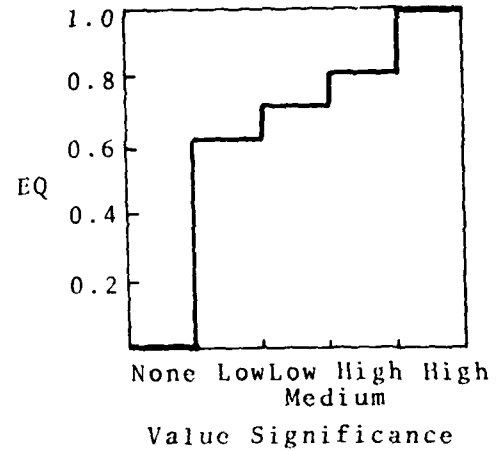


FIGURE 65. HISTORICAL EXTERNAL PACKAGES

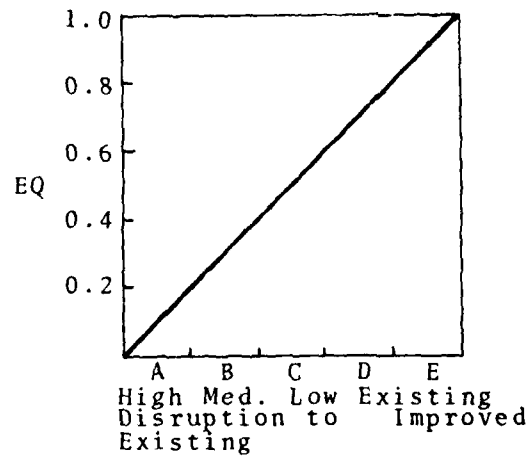


FIGURE 66. CULTURES

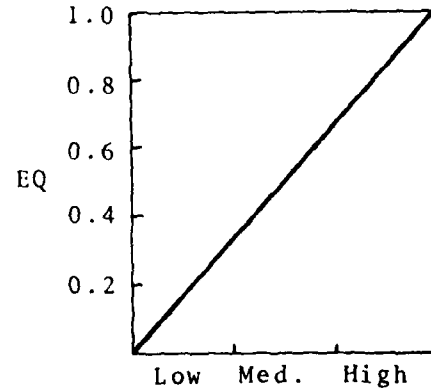


FIGURE 67. MOOD/ATMOSPHERE

A-20

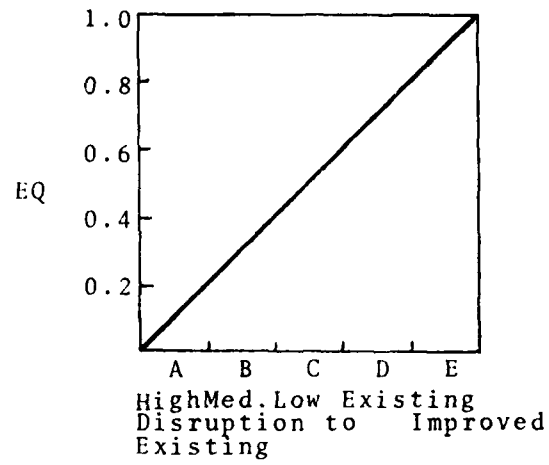
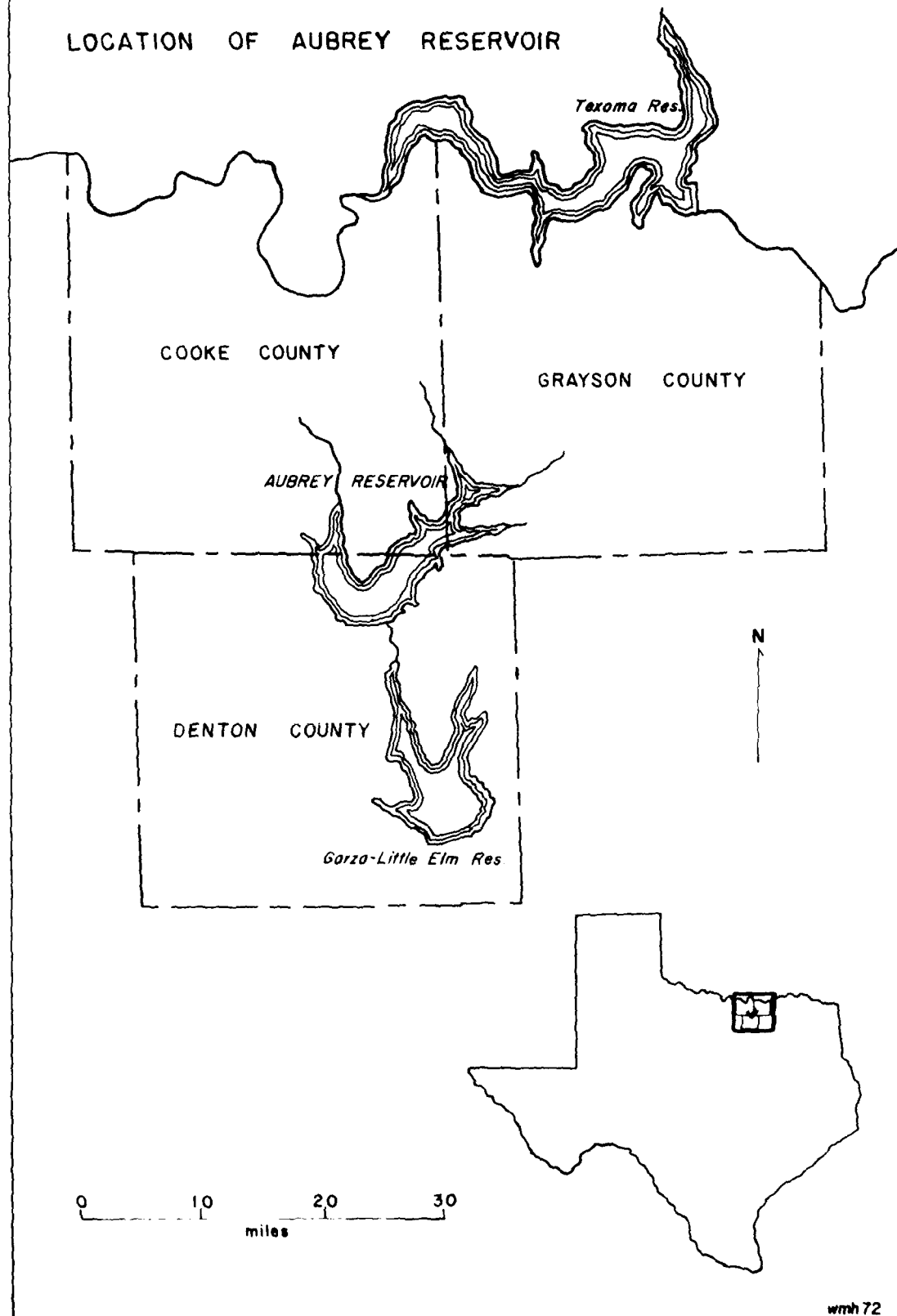


FIGURE 68. LIFE PATTERNS

APPENDIX B

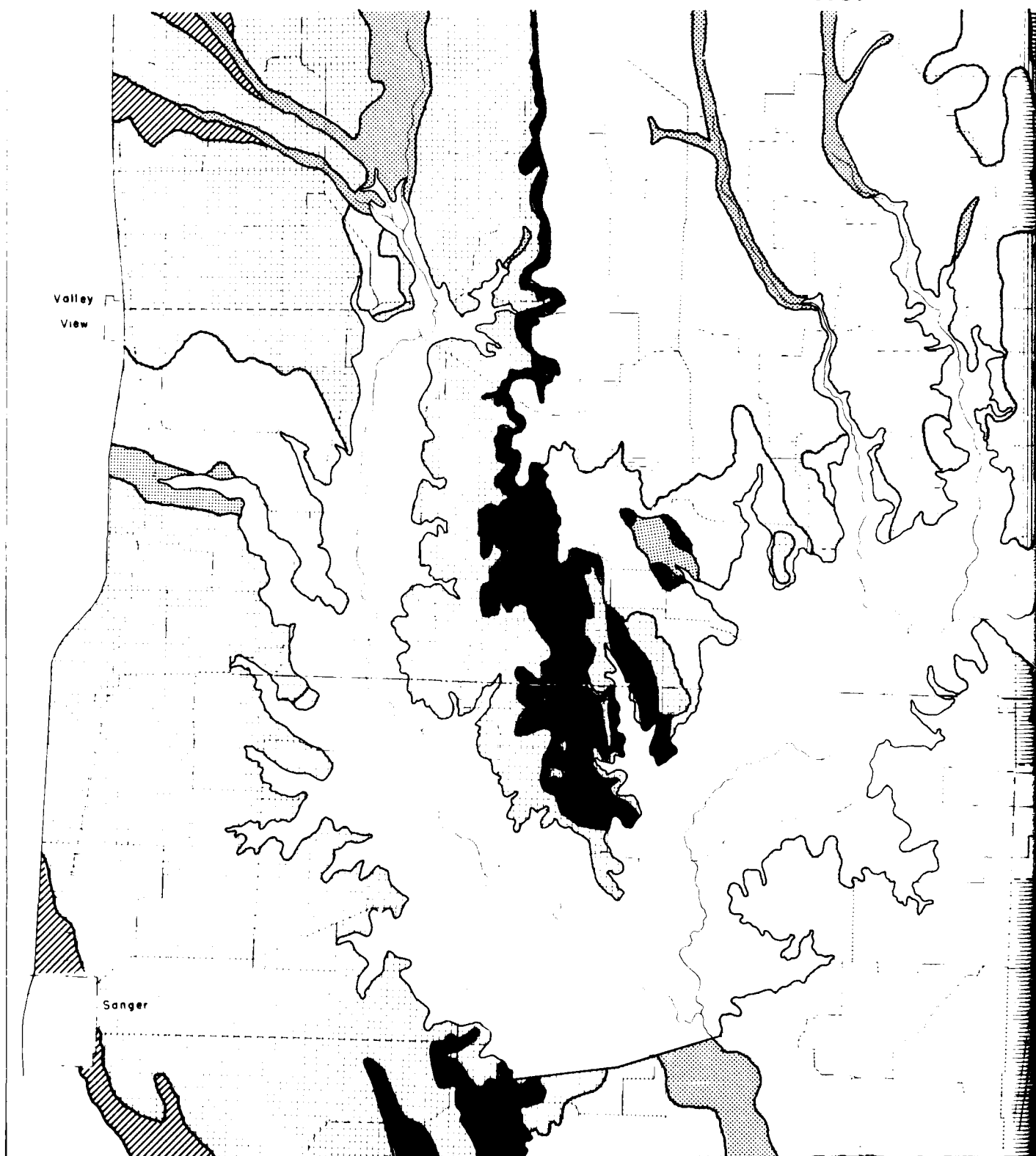
PLATES

LOCATION OF AUBREY RESERVOIR

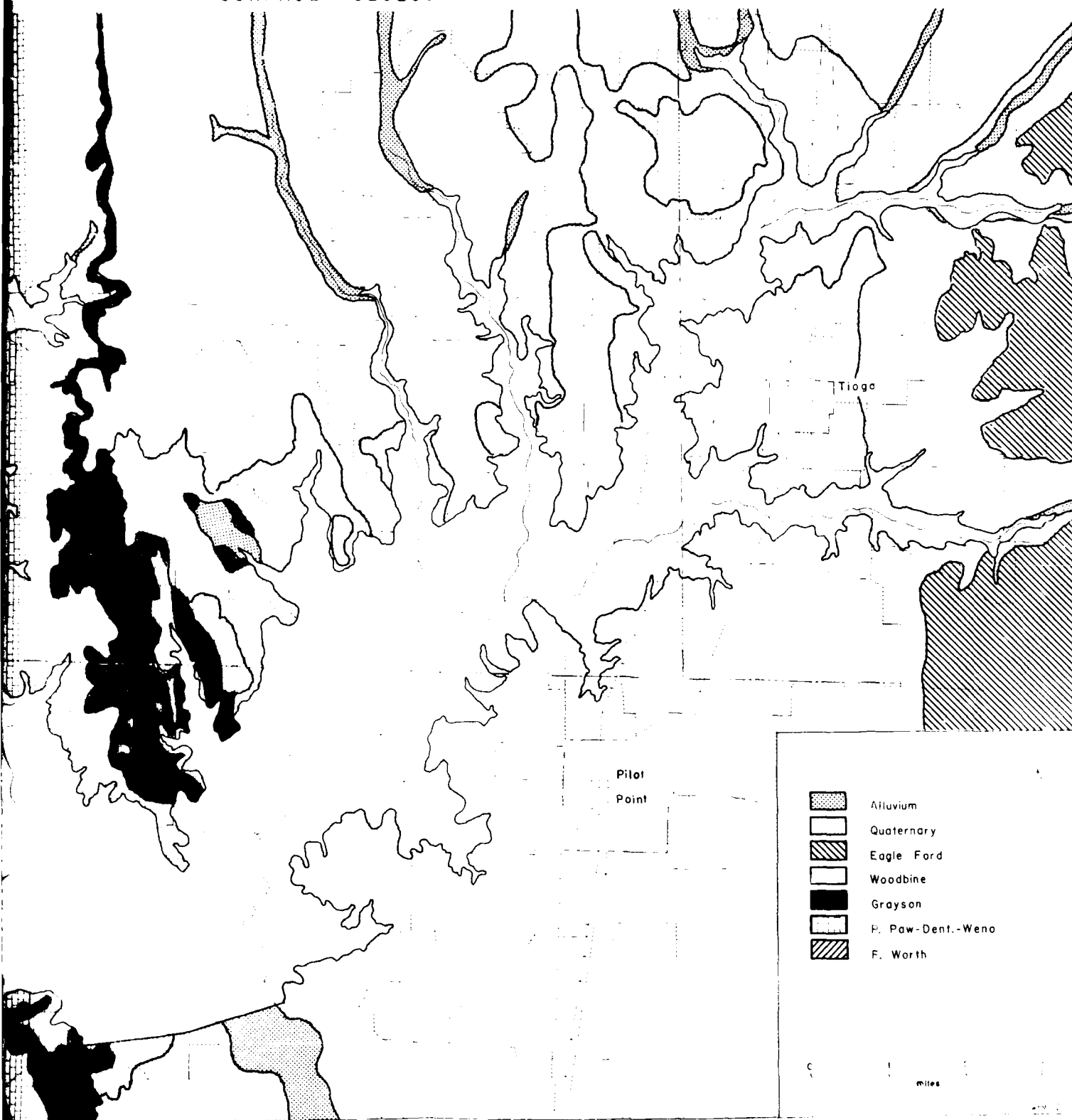


wmh 72

PROPOSED AUBREY RESERVOIR
SURFACE GEOLOGY



PROPOSED AUBREY RESERVOIR SURFACE GEOLOGY



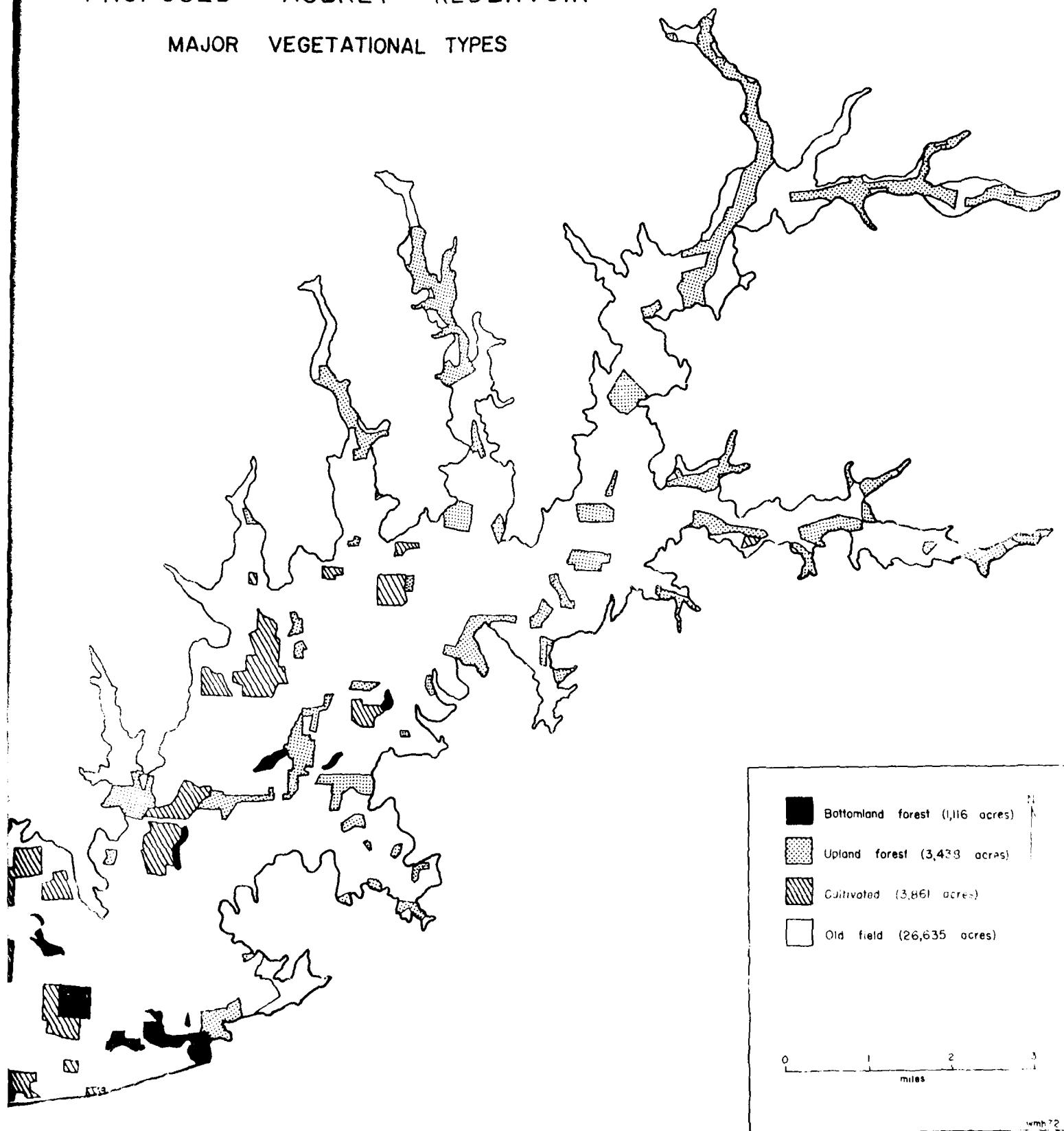
PROPOSED AUBREY RESERVOIR

MAJOR VEGETATIONAL TYPES



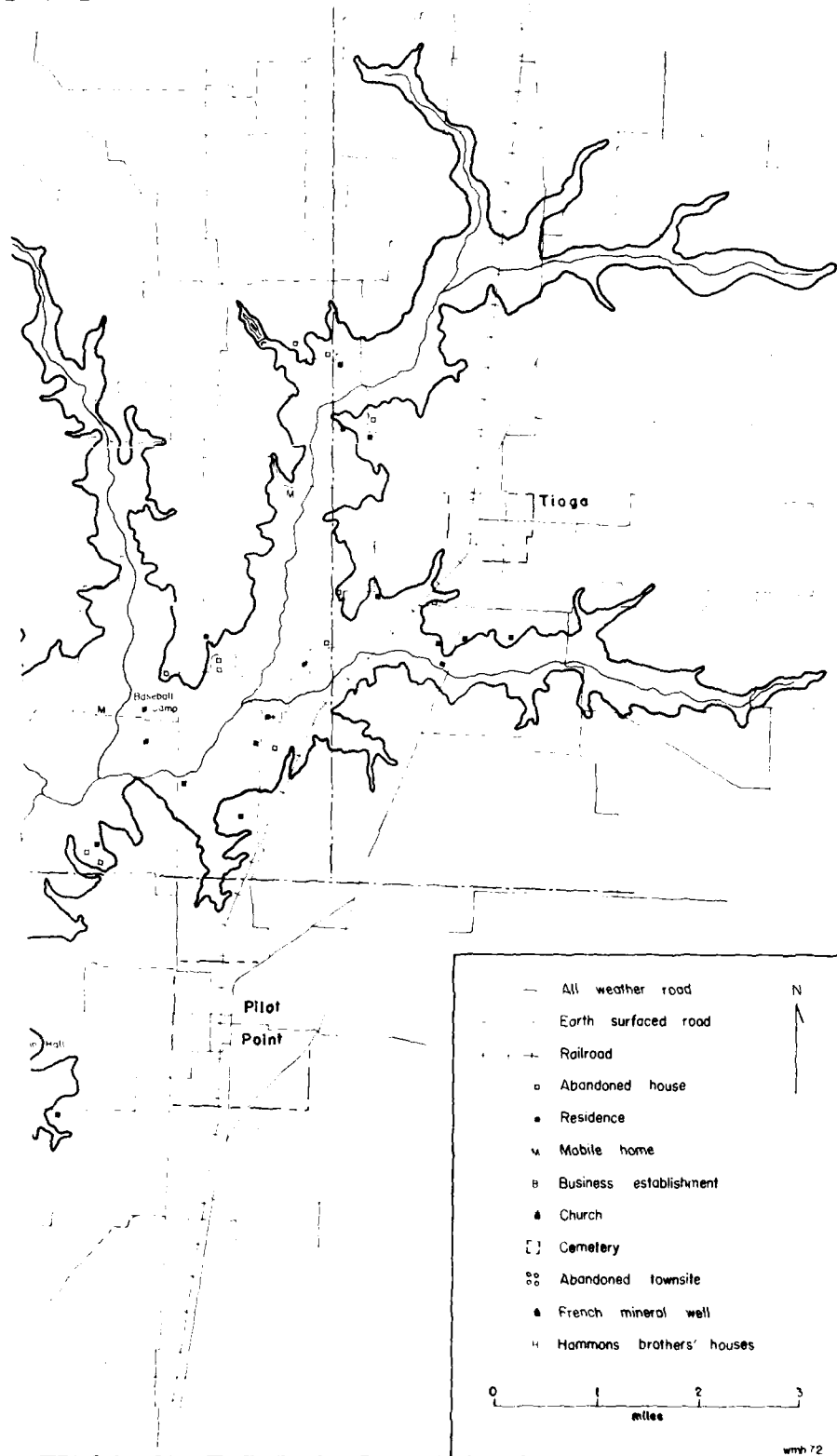
PROPOSED AUBREY RESERVOIR

MAJOR VEGETATIONAL TYPES

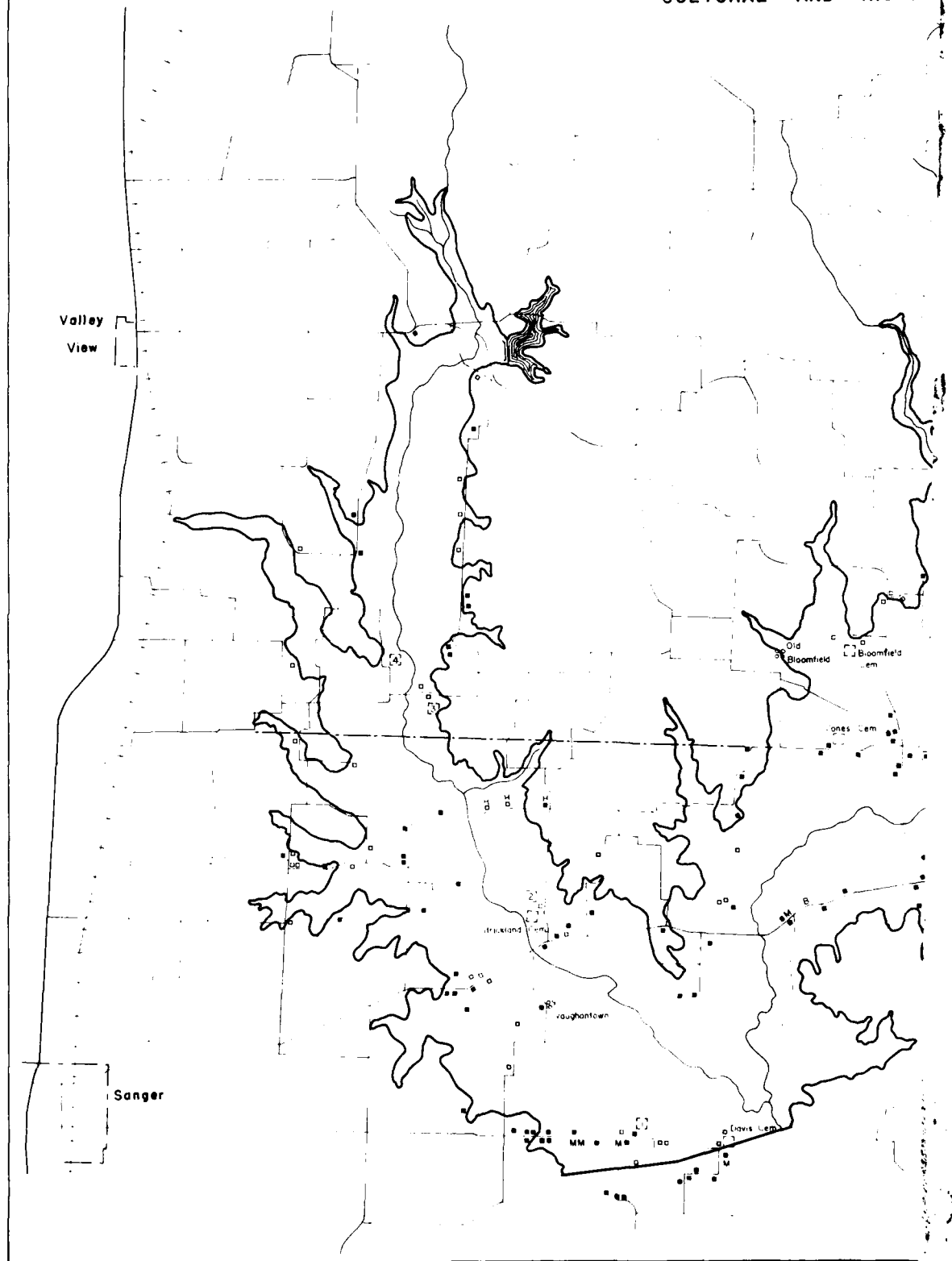


RESERVOIR

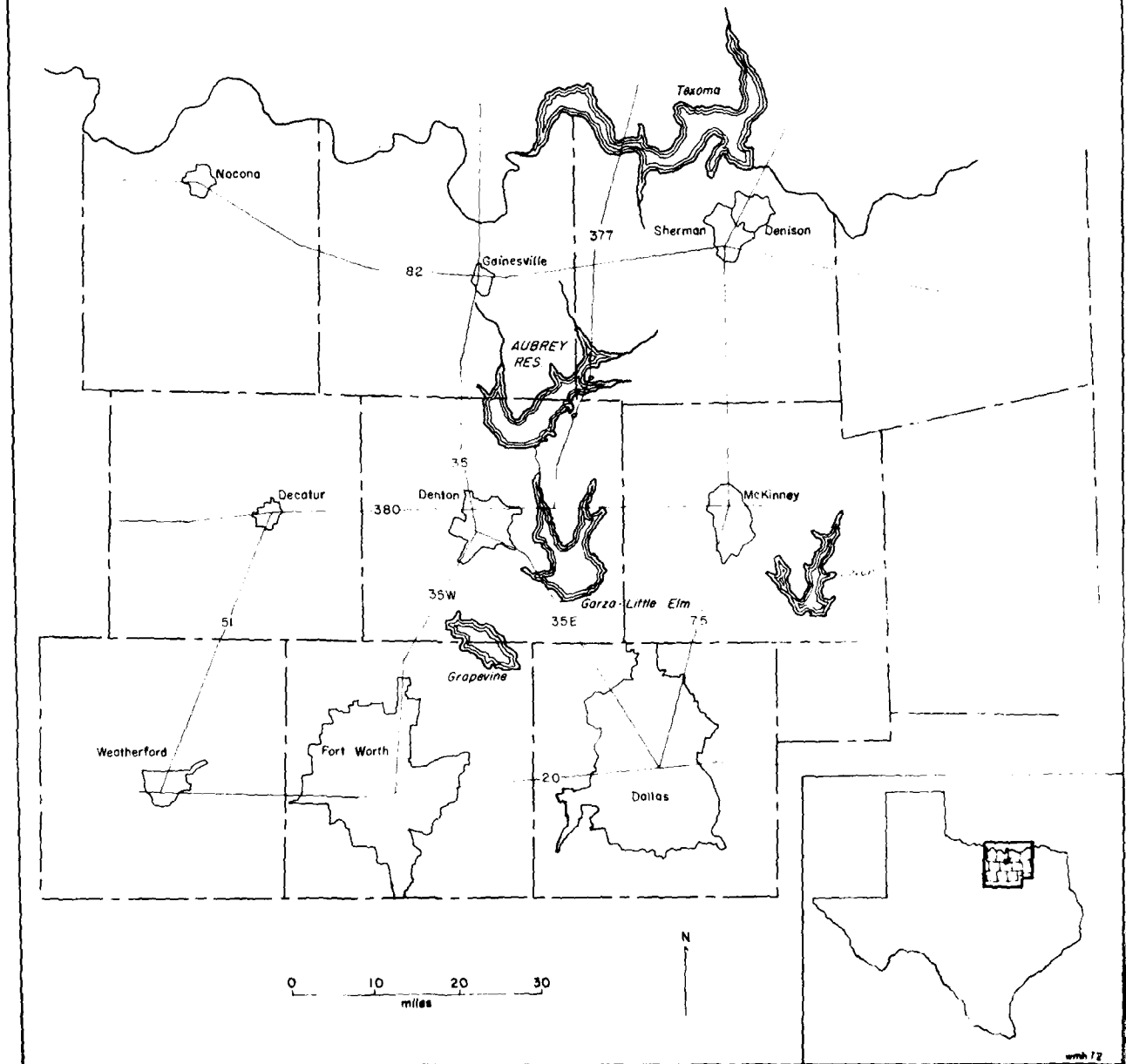
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PROPOSED AUBREY
CULTURAL AND HISTORICAL



AUBREY RESERVOIR AND VICINITY



APPENDIX C

LIST OF INVESTIGATORS AND CONTRIBUTIONS

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The Director of the Institute for Environmental Studies subcontracted the preparation of the EES parameter reports and the Environmental Element reports to the individuals listed below. Each investigator is solely responsible for the scientific content and merit of his report. The Editor is responsible for the following: 1) coordination of the study; 2) editing the manuscripts; 3) assembling and preparing the report; 4) writing the Introduction, Description of the EES and introduction to the EES components and categories.

| <u>Investigator</u> | <u>EES Reports</u> | <u>Environmental Element Report</u> |
|----------------------|--|--|
| Robert L. Abshire | Water Pollution Parameters Air Pollution Parameters Hydrological Package | Hydrological-Water |
| Lloyd C. Fitzpatrick | Species Diversity (Terrestrial) Ecosystems (Descriptive) | Zoological Elements: Amphibians and Reptiles |
| Lee G. Knox | Land Parameters Water Surface Area Wooded and Geological Shoreline | Geological-Physical |
| Robert A. Miller | Man-Made Objects Land Use (Pollution) Soil Erosion (Pollution) Life Patterns Parameters | Demographical- Economical- Cultural |
| E. Dale Odom | Archeological Package Historical Package Parameters Cultures Parameters | Archeological- Historical- Cultural |

| <u>Investigator</u> | <u>EES Reports</u> | <u>Environmental Element Report</u> |
|---------------------|--|--|
| William D. Pearson | Commercial Fisheries Sport Fish River Characteristics Appearance of Water Land and Water Interface Odor and Floating Materials | Zoological Elements: Fishes |
| A. W. Roach | Crops Natural Vegetation Land Use Diversity of Vegetation Types Variety Within Vegetation Types Ecological Package Mood/Atmosphere Parameters | Botanical Elements |
| Kenneth W. Stewart | Pest Species (Terrestrial) Pest Species (Aquatic) Food Web Index (Aquatic) Rare and Endangered Species (Aquatic) Species Diversity (Aquatic) Animals (Domestic) Noise Pollution | Zoological Elements Aquatic and Terrestrial Invertebrates |
| Earl G. Zimmerman | Browsers and Grazers Upland Game Birds Water Fowl Food Web Index (Terrestrial) Rare and Endangered Species (Terrestrial) Air Parameters Animals (Wild) | Zoological Elements: Birds and Mammals |

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